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GOLD DEPOSITS ASSOCIATED WITH FELSIC INTRUSIONS IN SOUTHWESTERN NEW BRUNSWICK—FIELD GUIDEBOOK

Kathleen Thorne and Malcolm McLeod (editors)

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With contributions from:
David Lentz, Xueming Yang, Matt Adams, Glenn Lutes, Sébastien Castonguay, Jean-François Ravenelle, Sheila Watters, Guoxiang Chi, and Don Hoy

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Itinerary

Wednesday May 7th, 2003
Participants arrive in Fredericton from Montreal

Day 1 - Thursday May 8th, 2003 (Clarence Stream – Main Zone)
Meet at 8AM (Fredericton Inn)
Clarence Stream (Trenches 1 and 4)
Travel to Mount Pleasant to examine core from the Clarence Stream deposit, Kedron, and Poplar Mountain occurrences
McDougall Brook showing in Mount Pleasant caldera
Return to Fredericton

Day 2 - Friday May 9th, 2003 (Clarence Stream – Anomaly A and Tower Hill)
Meet at 8AM (Fredericton Inn)
Clarence Stream (AD Trench at Anomaly A)
Tower Hill Au showing
Return to Fredericton

Day 3 - Saturday May 10th, 2003 (Springfield showing and Lake George)
Meet at 8AM (Fredericton Inn)
Travel to Springfield trenches northwest of Fredericton; examine available drill core
Examine drill core at the Lake George mine site
Return to Fredericton
Participants catch their flights

Preface

KATHLEEN THORNE
New Brunswick Department of Natural Resources and Energy;
Minerals, Policy and Planning Division, PO Box 6000, Fredericton, NB, E3B 5H1 (kay.thorne@gnb.ca)

The purpose of this trip will be to examine various gold deposits and occurrences which have temporal, spatial, and/or genetic links to local felsic intrusions in southwestern New Brunswick. The locations of the various deposits and occurrences to be covered by the field trip are shown in Fig. 1. The trip will be based in Fredericton and will take place over a 3 day period. The first day will begin by traveling to the Main Zone of the Clarence Stream gold deposit near Rollingdam in southwestern New Brunswick, where we will examine spectacular trenched exposures of mineralized quartz veins and granitic dykes hosted within the Silurian metasediments and metagabbroic dykes. Drill core from the Main Zone in addition to the Poplar Mountain and Kedron occurrences will be available for examination in the afternoon at the former Mount Pleasant mine site. If time permits, we will look at mineralized hydrothermal breccias within the Mount Pleasant Caldera on the return trip to Fredericton. The second day will entail visiting a large trenched exposure at the Anomaly A portion of the Clarence Stream gold deposit. Drill core will be available for examination at the trench site. We will then travel to the Tower Hill occurrence located to the west that is exposed in three trenches. The third day will begin with a visit to the Springfield gold property west of Fredericton where mineralized hydrothermal breccias will be examined in outcrops and drill core. We will then visit the former Lake George mine site where drill core will be available for examination. The trip will conclude in the afternoon in Fredericton.

Much of the research that is currently being conducted on the prospects, occurrences and deposits that will be visited and discussed during this field trip, forms a part of a Targeted Geoscience Intitiative project. The goal of this two year project was to characterize the metallogeny of intrusion-related gold systems in southern New Brunswick. This research is a collaborative effort between researchers at the Geological Survey of Canada, University of New Brunswick, Natural Science and Engineering Research Council (grant to Prof. D. Lentz), Freewest Resources Canada Incorporated, and the New Brunswick Department of Natural Resources and Energy.

The field trip organizers would like to thank Freewest Resources Canada Inc. for making this trip possible by allowing access to their properties and their information, and for their help to organize this field trip. Also, the contributing authors to this guidebook and those helping out in the field deserve special thanks in recognition of their efforts. Carol McNeil-Dobbelsteyn was instrumental in organizing registration and other logistics pertaining to the field trip. A special thanks to Maurice Mazzerolle for being brave enough to chauffeur us all around on muddy roads. Also, Terry Leonard, Maurice Mazzerolle, and Ken Mersereau are thanked for their work in preparing the majority of the diagrams.

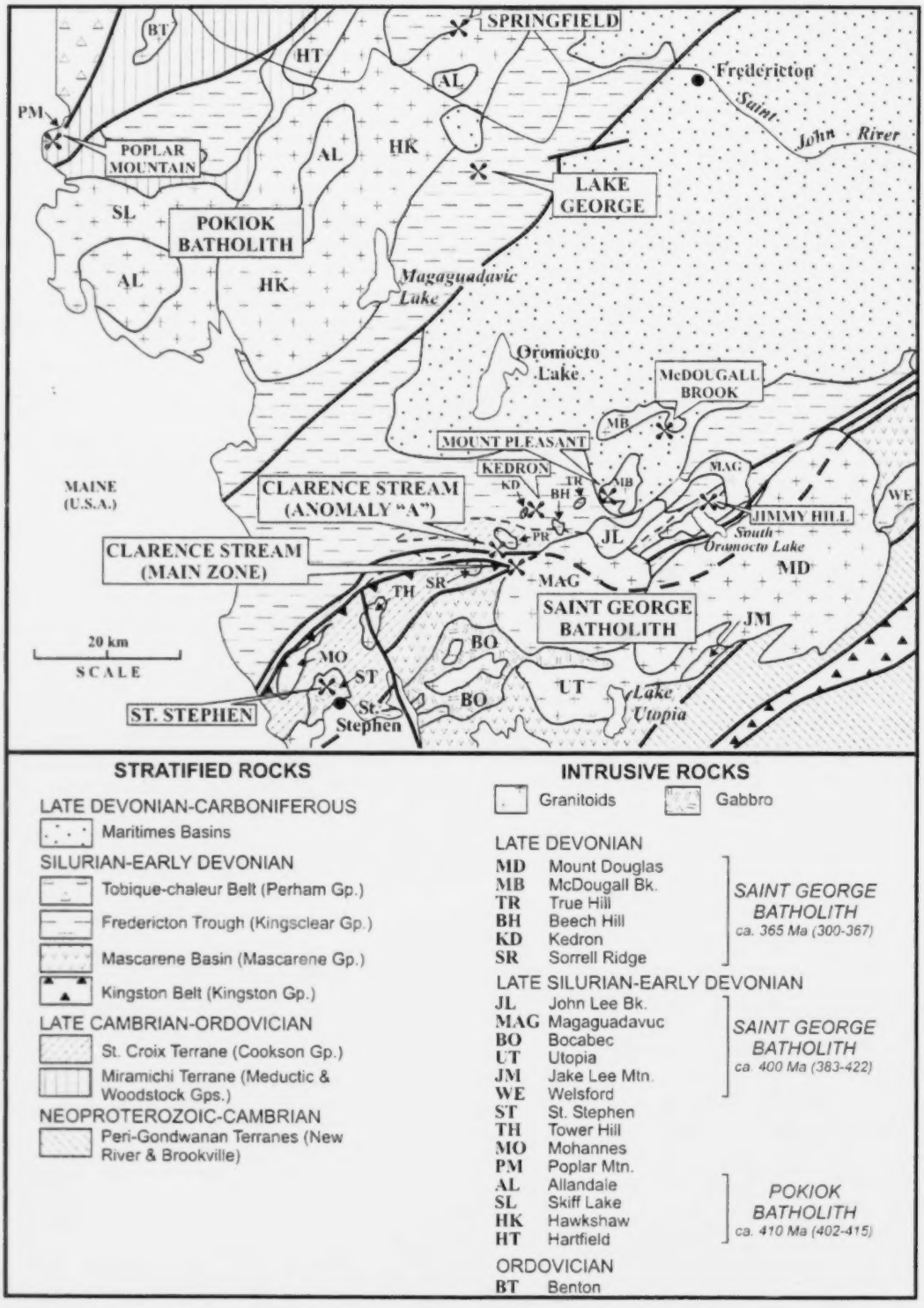

Figure 1. Geology map of southwestern New Brunswick showing locations of the gold occurrences and deposits discussed in this guidebook.

Regional Geology of Southwestern New Brunswick

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Introduction

The New Brunswick segment of the Appalachian Orogen records a complex history of Late Neoproterozoic and Paleozoic extensional and accretionary tectonic episodes that culminated in continental collision events (e.g. Fyffe and Fricker, 1987; van Stall et al., 1998; Fyffe et al., 1999; Barr et al., 2002). Consequentially, a host of environments were established in the province for the formation of gold deposits (Ruitenberg et al., 1990; McLeod and McCutcheon, 2000; McLeod and Fyffe, 2002). Paramount among these at present, particularly in southern New Brunswick, are the deposits generated by emplacement of extensive plutonic suites late in the orogen's development. The recently recognized potential of these intrusion-related environments to form world class gold deposits (McLeod and McCutcheon, 2000; Thorne et al., 2002; Thorne and Lentz, 2003) has generated significant exploration for gold in the region. This field trip will focus on these and provide insights into several deposit types associated with the felsic intrusions located in the southwestern portion of the province.

Tectonic Evolution

In the broadest sense, four main continental blocks were involved in the development of the Appalachian Orogen of New Brunswick (Fig. 1). The Grenville

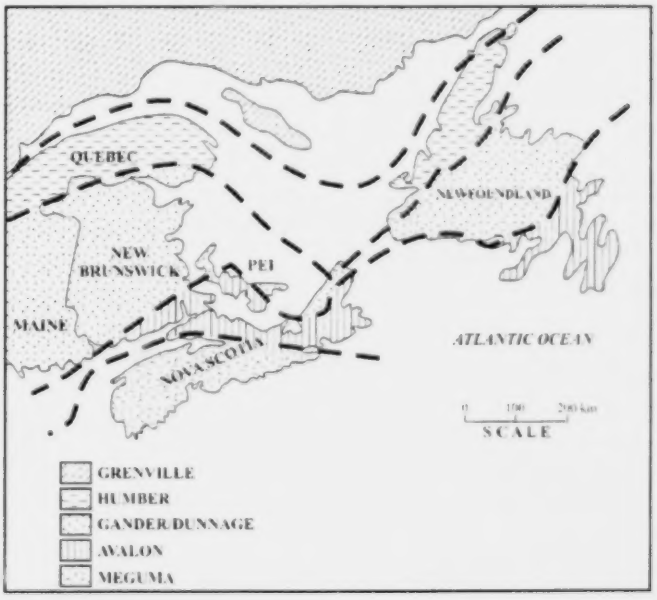

Figure 1. Tectonic divisions of the Atlantic Provinces (modified after Williams, 1995; Barr and White, 1996).

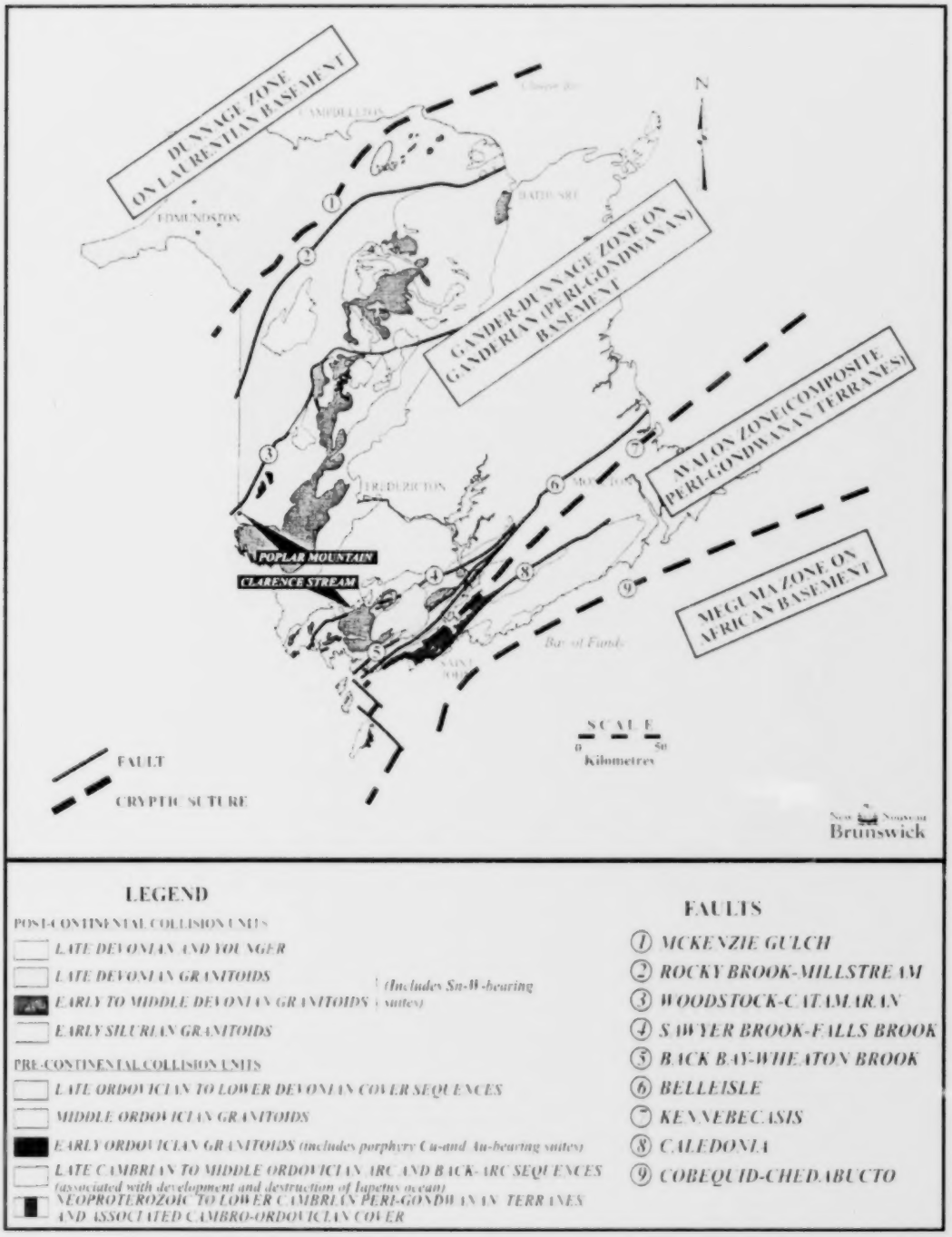

Figure 2. Tectonostratigraphic belts of New Brunswick (after McLeod and Fyffe, 2002).

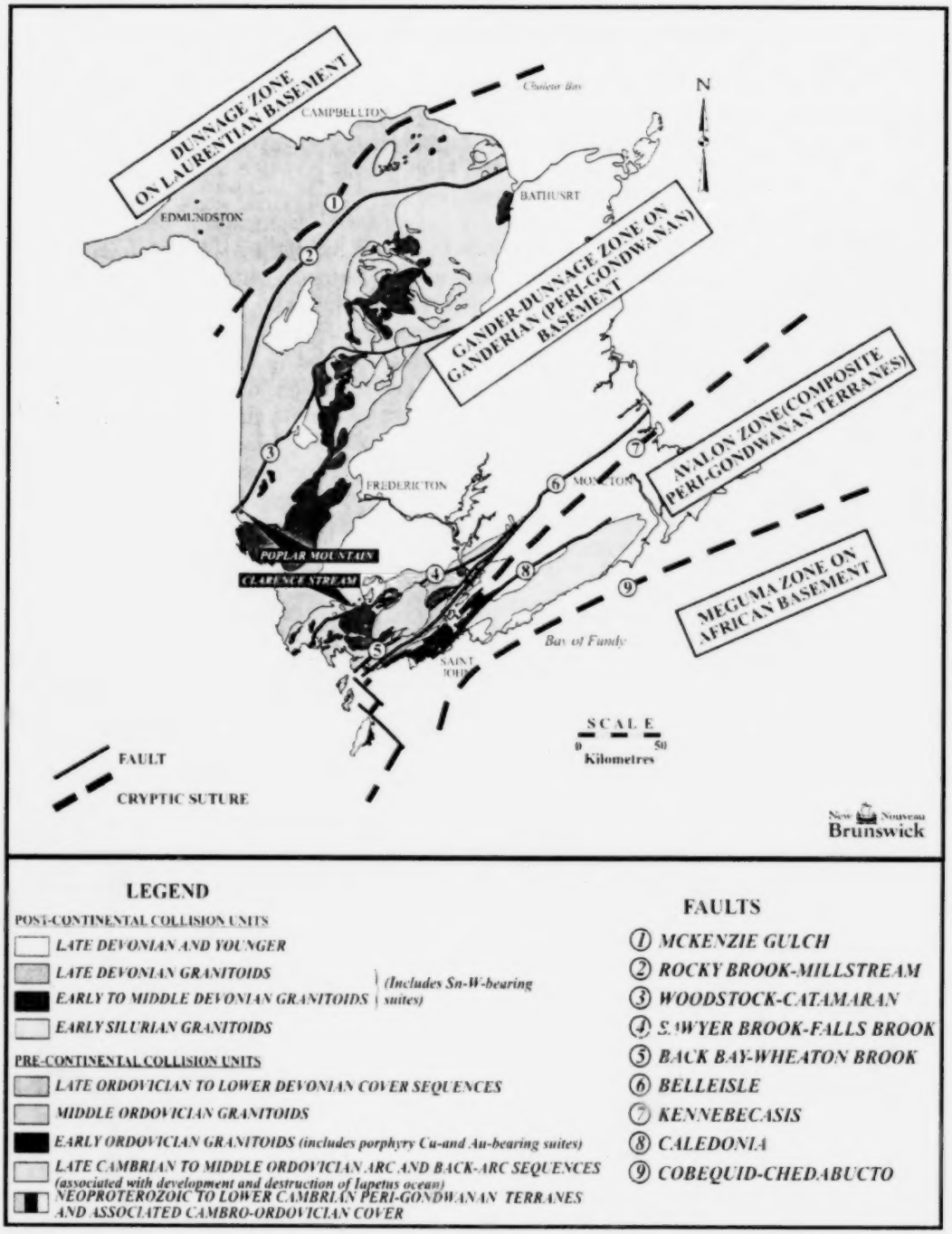

Figure 2. Tectonostratigraphic belts of New Brunswick (after McLeod and Fyffe, 2002).

and Humber zones comprise one block that forms the eastern part of the ancient North American craton and its continental platform. The second, the Gander/Dunnage Zone, represents the Cambro-Ordovician central mobile belt of the orogen and contains vestiges of the Avalonian continental margin, arcs and related back-arc basins, and plutonic suites that mostly formed along the southern margin of the Early Paleozoic Iapetus Ocean. The third and fourth are the composite Avalon Zone that contains peri-Gondwanan terranes and the Meguma Zone that represents a fragment of ancestral Africa left behind after opening of the present-day Atlantic Ocean. The general distribution of these Late Neoproterozoic and Early Paleozoic terranes or tectonostratigraphic belts is shown in Fig. 2.

Preceding cessation of tectonism related to the collision of the Avalon and Gander/Dunnage zones against the North American craton, subduction-related magmatism continued within and adjacent to the mobile belt. During this time, related extensional basins and foredeep depocentres filled with detritus from advancing continental blocks (e.g. Fyffe and Fricker, 1987; van Stall et al., 1998; Fyffe et al., 1999). These are collectively designated as Late Ordovician to Early Devonian cover sequences in Fig. 2.

Voluminous, synorogenic to postorogenic, Late Silurian to Late Devonian, "I"- and "A"-type plutonic suites were generated across the orogen as the main continental collision event terminated (Figs. 1 and 2). In southern New Brunswick, these multiphase intrusions are preserved as the Saint George and Pokiok batholiths, and associated intrusions (e.g. Lutes, 1987; MacLellan et al., 1990; McLeod, 1990; Whalen, 1993).

In the wake of these events during Late Devonian through Permian time, extensive successor basins formed burying large portions of the orogen (Fig. 2). Late in the development of these basins, the Meguma Terrane of Nova Scotia was emplaced along a major structural dislocation now bordering the southern margin of the Avalon Zone (e.g. Nance, 1987). Affects of this event are well documented in the thrust-fold belt in Avalonian and successor basin rocks along the south coast of the province (Nance, 1987; Watters, 1993).

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Geology of the Main Zone of the Clarence Stream Gold Deposit, Southwestern New Brunswick

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Introduction

Mineralization at the Clarence Stream gold deposit is structurally bound within a broad NE-trending dextral brittle-ductile shear zone along the northwestern margin of the Saint George Batholith near Rollingdam in southwestern New Brunswick. Freewest Resources Canada Incorporated has defined numerous mineralized zones through various geochemical and geophysical surveys, as well as several trenching and drilling programs. Gold mineralization occurs primarily within sulphide-bearing fault-fill quartz veins and is also disseminated throughout the host rocks, which include variably hornfelsed metasedimentary units and a swarm of metagabbroic and granitic dykes. Studies have demonstrated a genetic link between gold mineralization at the Main Zone of the Clarence Stream deposit and the nearby Magaguadavic Granite that occurs along the southern boundary of the property (Thorne et al., 2002; Thorne and Lentz, 2003), thus supporting an intrusion-related genetic model for exploration.

Exploration History

Prospecting by Reg Cox Jr. in the Clarence Stream area was initiated following the release of results obtained from a regional stream sediment survey conducted by the Geological Survey of Canada in 1992 (Friske et al., 1992). This survey defined numerous gold anomalies near what is now known as the Main Zone of the Clarence Stream deposit, where he discovered several angular quartz vein boulders containing significant gold values. Freewest Resources Canada Incorporated optioned the property in 1999 and uncovered additional mineralization both in float and in outcrop over a 2 kilometre strike length. To effectively explore and realize the mineral potential of the area, they cut a 2.5 kilometre grid over the favourably mineralized zone and immediately began a B-horizon soil sampling survey followed by induced polarization (IP) and total field magnetic surveys. The results of the soil survey provided two distinctive anomalous zones referred to as the West and East zones. There were several other smaller anomalous zones defined as well, however, much of the exploration activities were initially focussed within the two most prominent anomalies.

Geological mapping and sampling of the grid, concurrent with trenching of the soil anomalies, were conducted during the summer of 2000. Numerous heavily altered and mineralized zones were uncovered, including auriferous quartz veins up to 3 metres in width. Later in the summer, Freewest extended the original grid to the east, west, and northwest in their search for additional mineralized areas.

In January 2001, a 3,474 metre diamond drilling program began that intersected 21 metres averaging 15.06 g/t Au at a vertical depth of 60 metres (Robertson, 2001) on the western portion

of the property. A second phase of drilling outlining the Central Zone commenced in June 2001, which continued to produce spectacular grades that included 12.5 metres averaging 6.64 g/t Au, 7.21 g/t Au over a width of 12 metres, 14.9 metres of 7.8 g/t Au, and 9.5 metres of 21.51 g/t Au (Robertson, 2001). To date, a drill-indicated resource of 126,000 ounces with an average grade of 7.2 g/t Au has been defined at the Central Zone alone and remains open at depth and along strike (Robertson, 2002).

Regional exploration proximal to the Main Zone of the Clarence Stream deposit by Freewest Resources led to the discovery of additional target areas that contained significant mineral potential. Since then, Freewest has focussed their attention on what is referred to as Anomaly A, which is situated approximately three kilometres to the northwest of the Main Zone (see Lutes et al., this volume).

Regional Geological Setting

The Clarence Stream gold deposit is situated proximal to a major tectonostratigraphic boundary, which is represented at the surface by the syn- to post-depositional Sawyer Brook Fault (SBF; Fyffe et al., 1999; Fig. 1). This fault separates the Ordovician St. Croix Terrane of the Gander Zone to the northwest from the peri-Gondwanan New River Terrane to the southeast. Accretion of these two terranes occurred during the mid-Paleozoic (Williams and Hatcher, 1982) and was followed by deposition of the Silurian sedimentary and volcanic sequences of the Mascarene Group. This sequence obscures the exact position of the suture zone. Major transcurrent movement (transpressional to transtensional) along this terrane boundary during the Appalachian Orogeny (Williams and Hatcher, 1982) reactivated this boundary and related structures (e.g., SBF). Cogenetic mafic magmas underplated the region facilitating crustal melting that led to the emplacement of the bimodal Saint George Batholith (SGB; McLeod, 1990; Whalen et al., 1994). This composite intrusion, characterized by A- and I-type intrusions, represents a stitching pluton between the two terranes (McLeod, 1990) and intrudes the cover sequence. Several Late Devonian Sn-W-Mo-bearing evolved granitic satellite plutons known as the Pomeroy Intrusive Suite (McLeod, 1990) intrude along the northwestern margin of the SGB (Fig. 1).

Rocks of the St. Croix Terrane along the northwestern margin of the Sawyer Brook Fault (Fig. 2) include Ordovician clastic sedimentary rocks of the Kendall Mountain, Calais, and Woodland formations (Fyffe et al., 1999). Initial stages of polyphase deformation (D_1 and D_2) experienced by these rocks occurred during a protracted NW-directed compressional event associated with the thrusting of the St. Croix Terrane onto the Fredericton Belt in Salinian to early Acadian time (Ruitenberg and Ludman, 1978; Ludman, 1991). The younger rocks along the southeast margin of the SBF that host the Main Zone of the Clarence Stream deposit (Silurian Oak Bay and Waweig formations) are dominated by a fabric that Castonguay et al. (2003) assign to a regional D_3 event. Castonguay et al. (2003) interpret the Sawyer Brook Fault as a late-D_3 dextral strike-slip fault that cuts the southeastern limb of the regional scale St. David antiform. This phase of deformation overprints the earlier fabrics in the Ordovician rocks, however, there is no physical evidence to suggest that the Silurian rocks have experienced the two previous deformation events. This may be a result of complete obliteration or transposition of the earlier

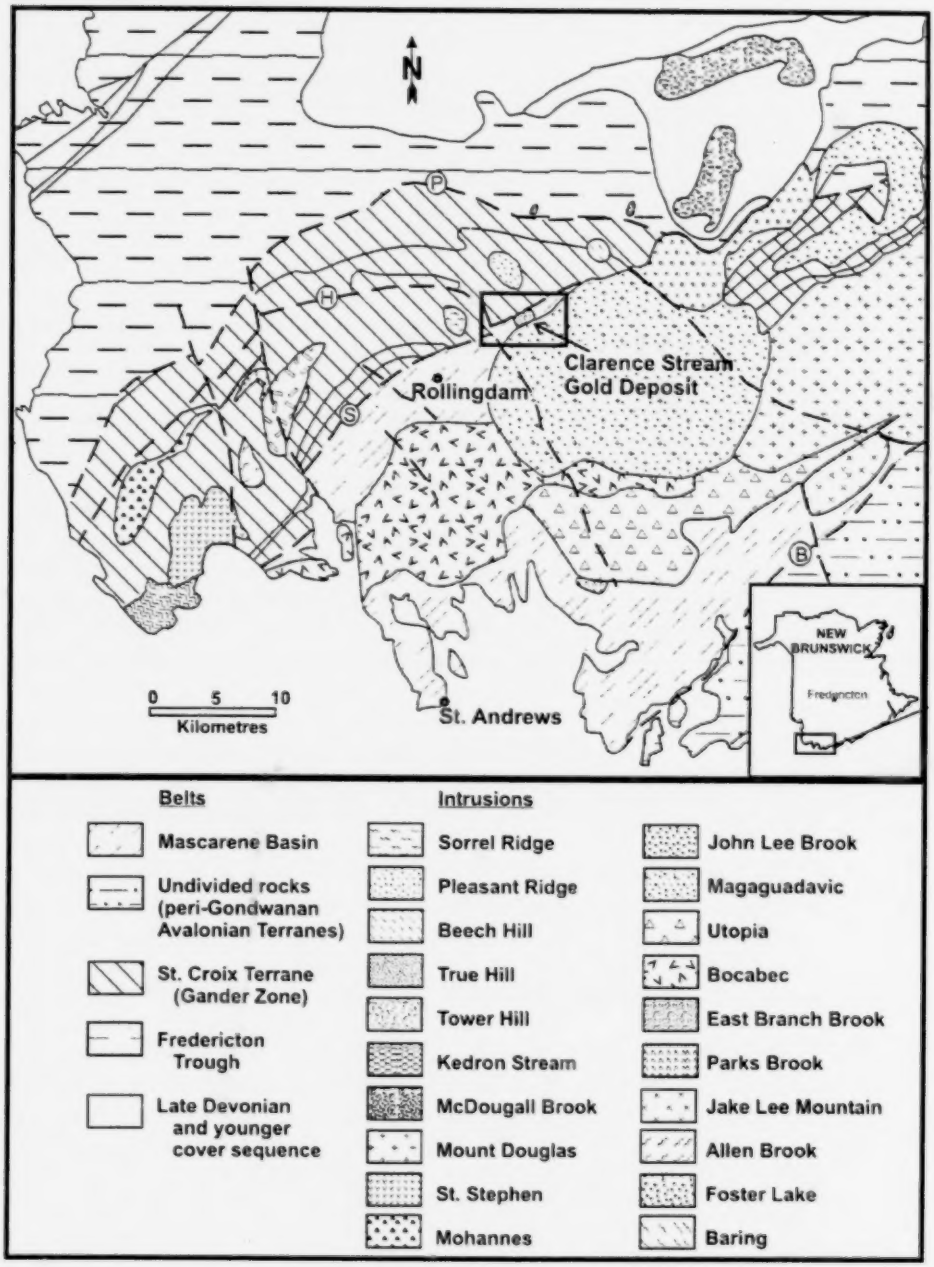

Figure 1. Regional geology of the Clarence Stream area. Circled letters symbolize major faults in the area that include P – Pendar Brook, H – Honeydale, S – Sawyer Brook, and B – Belleisle. Geology compiled after McLeod (1990), McLeod et al. (1998), and New Brunswick Department of Natural Resources and Energy (2000).

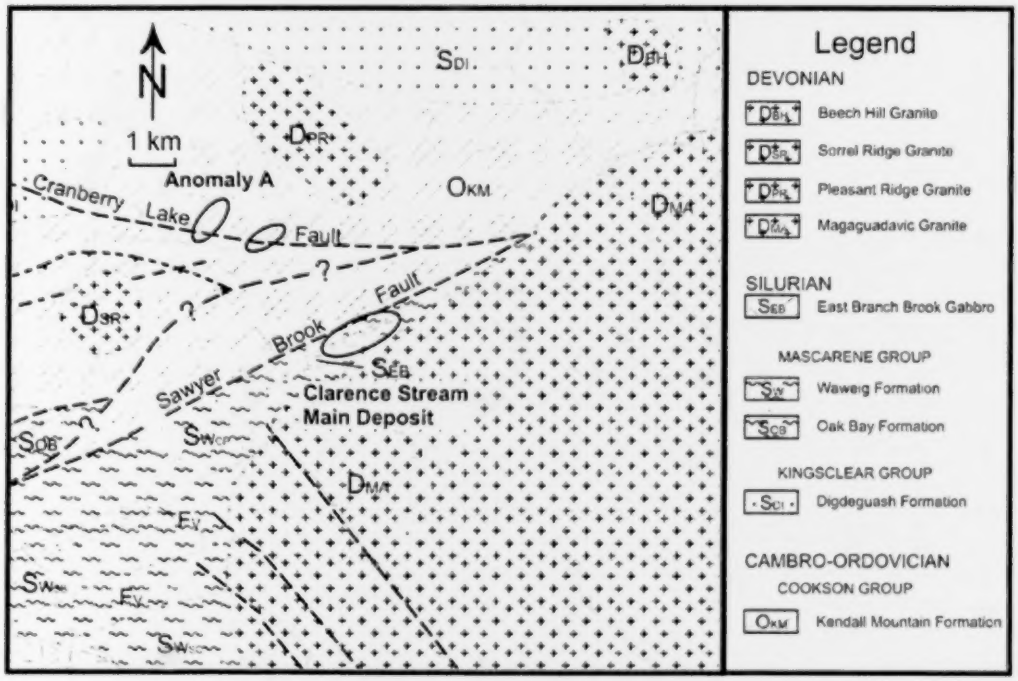

Figure. 2. Regional geology of the zones of mineralization at the Clarence Stream gold deposit. Geology modified from Fyffe (1997) and McLeod et al. (1998).

fabrics during the D_3 event as a function of the proximity to the fault zone boundary (SBF). NW-trending fault zones that correspond to a D_4 event (Ruitenberg, 1967; Castonguay et al., 2003) are seen in both the Ordovician and Silurian rocks. Castonguay et al. (2003) consider late kink bands to be D_5 structures.

Local Geological Setting

Fault-fill auriferous quartz veins hosted within a broad, dextral brittle-ductile shear zone comprise the Clarence Stream gold deposit near Rollingdam in southwestern New Brunswick. The shear zone cuts across a suite of Silurian metasedimentary units belonging to the Mascarene Group that have been intruded by a swarm of both mafic and felsic intrusions. Mineralization is primarily focussed within two areas on the property (Fig. 3) referred to as the West and East zones. The West Zone has been divided into the West, Cox, N and Central zones as is seen in Fig. 3.

The lithological units exposed within the grid area include the Kendall Mountain and Waweig formations, the Magaguadavic Granite, as well as the newly introduced East Branch Brook metagabbros (Thorne and Lentz, 2001b). The bulk of the mineralization is hosted within the metasedimentary units of the Waweig Formation and the East Branch Brook metagabbros that occur within the contact aureole of the Magaguadavic Granite. The distribution of these units at the West and East zones is shown in Figs. 4 and 5. Brief descriptions of each of these units given in chronological order are as follows:

Kend[illegible]ain Formation (OKMmc)

The K[illegible] Mountain Formation is situated along the northern margin of the property and is sep[illegible]om the younger units by the inferred presence of the Sawyer Brook Fault. This formation [illegible] part of the Ordovician Cookson Group (Fyffe et al., 1999), and typically consists of interbedded shale, siltstone, and minor conglomerate (McLeod et al,, 1998) in addition to minor amounts of basalt. The presence of graptolites within slatey units suggests an age of Early Carodocian (Fyffe and Riva, 1990).

Waweig Formation (SWAfc, SWAv, SWAfv)

An assemblage of Late Silurian brachiopods that are a typical shallow-water fauna, have been found within this formation (Fyffe and Riva, 1990), which has been divided into three members, namely the Campbell Point, Sawyer Brook, and Simpson Corner members (Fyffe et al., 1999). A brief description of each taken from Fyffe et al. (1999) is as follows:

(1) *Campbell Point Member*: consists of interstratified volcaniclastic and siliciclastic sedimentary and felsic volcanic rocks, in which bedding and younging direction are to the southeast. It is further divided into 5 self-explanatory lithofacies that include a bedded tuffaceous sandstone facies, a chaotic tuffaceous sandstone facies, a waterlain pyroclastic facies, a medium- to thick-bedded sandstone facies, and a thin-bedded mudstone facies.

(2) *Sawyer Brook Member*: includes pyrite-bearing grey to black shales interbedded with dark greyish green mafic tuffs. These rocks are interpreted to have been deposited during hemipelagic sedimentation by means of low-density turbidity currents throughout an extended period of diminishing felsic volcanic activity.

(3) *Simpson Corner Member*: light pinkish grey, fine-grained sandstone grading into dark grey laminated silty mudstone are the dominant siliciclastic sedimentary rocks in this unit. There are also minor volcanic rocks interstratified locally that consist of both mafic and felsic end-members. The conditions under which these beds were deposited are not well understood, although they are thought to be deposited in a deep-water environment.

The Clarence Stream deposit is hosted within the Campbell Point Member of the Waweig Formation. Outcroppings of this unit reveal that this unit has been overturned (F_2) and have experienced a hornfelsing event. Volcaniclastic sandstones interbedded with felsic tuffs are the predominant lithologies in this area and these are commonly metamorphosed to biotite-cordierite-muscovite hornfels.

East Branch Brook Metagabbro (SEBmi)

The East Branch Brook intrusion is comprised of three phases (Fe-rich, intermediate, Mg-rich) of subalkaline to alkaline continental tholeiitic gabbro dykes (Thorne and Lentz, 2001b). They range from fine- to coarse-grained, melano- to leucocratic types and exhibit chilled

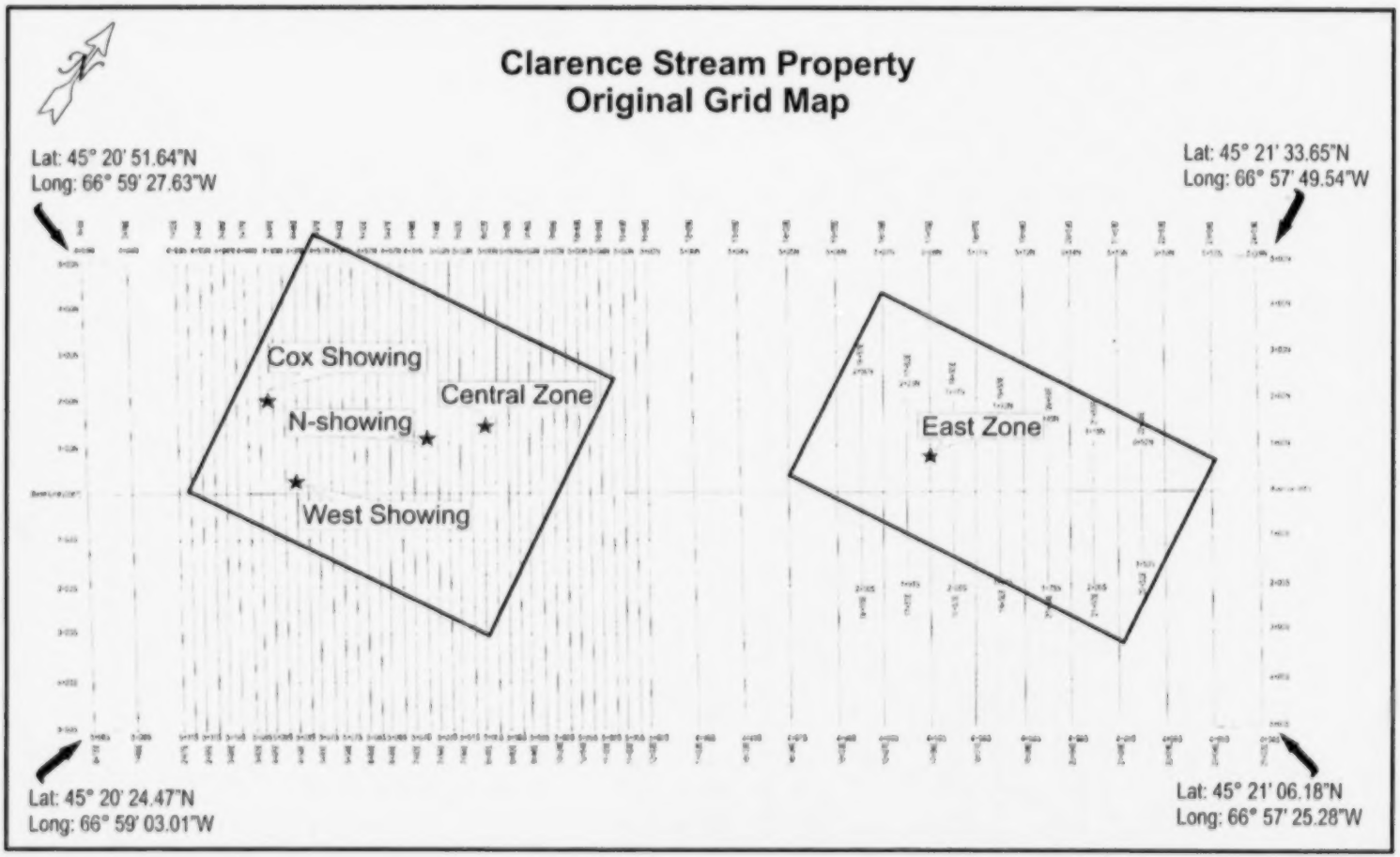

Figure 3. Location of mineralized zones within the Main Zone of the Clarence Stream deposit.

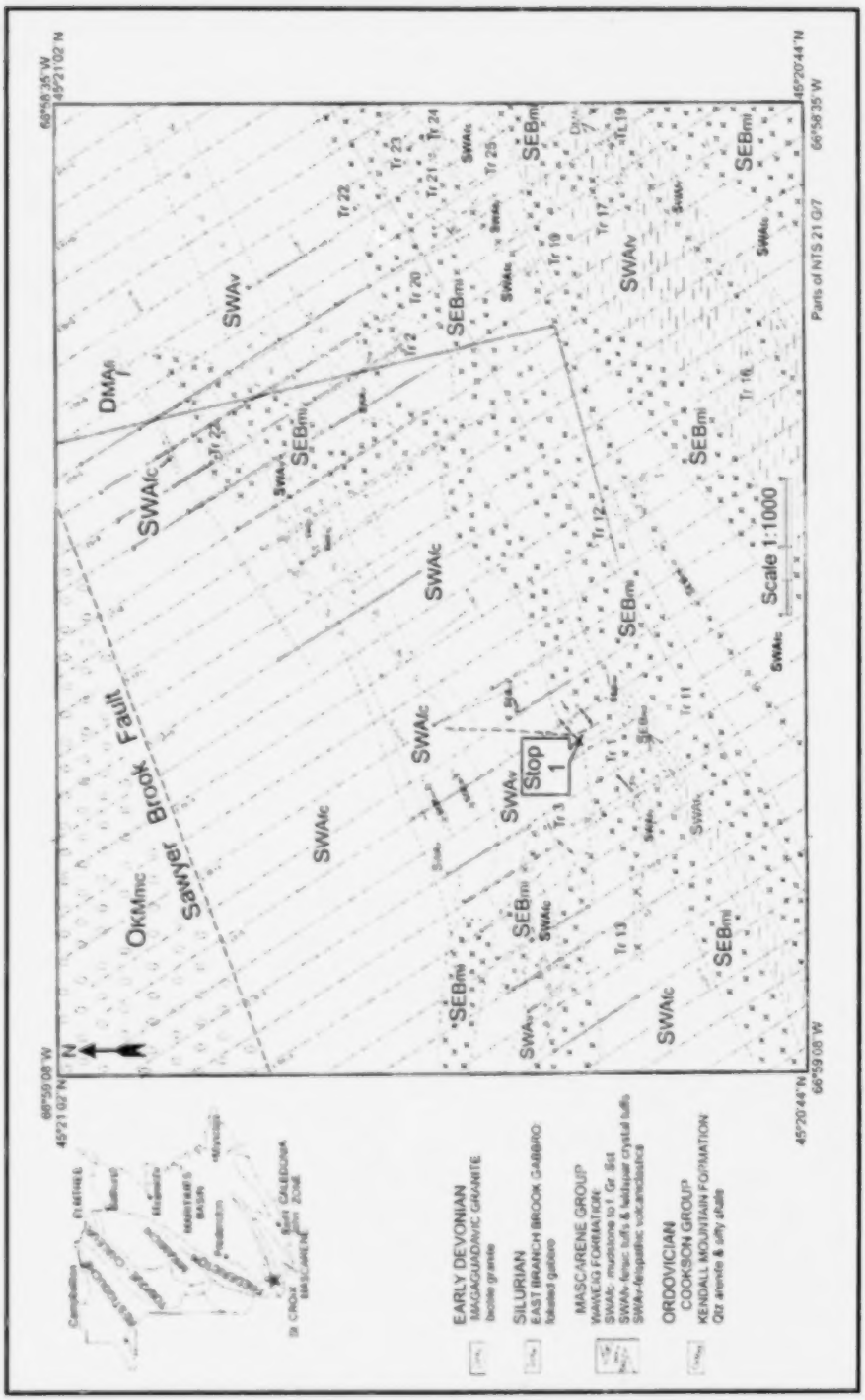

Figure 4. Local geology of the West Zone. Geology by Thorne, Lutes and Fyffe.

Figure 5. Local geology of the East Zone at the Clarence Stream gold deposit. Geology by Thorne, Lutes, and Fyffe.

margins. The magmas from which these dykes were derived were emplaced in a transpressional environment during faulting and rift-related events that occurred during Early Silurian to Early Devonian time (Thorne and Lentz, 2001b). Variable alteration (biotitization, saussuritization, and amphibolitization) of these mafic bodies is a function of the degree of shearing as well as relative age. Geochemical analysis of these dykes indicates that they are geochemically similar to the Early Devonian Bocabec Gabbro (403 Ma; Currie, 1988). Although an exact age has not been determined for these dykes, it is clear that they are younger than the volcanic and volcaniclastic sedimentary rocks that they intrude (438 ± 4 Ma, zircon; Miller and Fyffe, in preparation) but no older than the granitic dykes that intrude them (390 ± 8 Ma, monazite; Thorne et al., 2002).

Magaguadavic Granite (DMAfi)

The Magaguadavic Granite belongs to the South Oromocto Suite of the Saint George Batholith (McLeod, 1990) and underlies the southern portion of the Clarence Stream property. As described by McLeod (1990), this unit consists of pink to grey, medium- to coarse-grained monzogranite; however, in the vicinity of the Clarence Stream property, granodiorite predominates. The intrusion is a metaluminous to slightly peraluminous, I-type, magnetite-bearing medium- to coarse-grained porphyritic to megacrystic intrusion commonly containing abundant, variably assimilated metasedimentary xenoliths (McLeod, 1990). The main mass of the intrusion is comprised of a coarse-grained phase that is crosscut by a finer grained, more evolved phase with associated mineralization (McLeod, 1990). $^{40}Ar/^{39}Ar$ age dating of biotite within this unit returned an age of 400 ± 4 Ma (McLeod, 1990) that overlaps with a younger U-Pb (zircon) age of 396 ± 1 Ma obtained by Bevier (1990). This megacrystic intrusion has an I-type geochemical signature and contains biotite and/or hornblende, plagioclase, potassium feldspar, quartz and titanite (McLeod, 1990). Rapakivi texture of the potassium feldspars is common near the intrusive contact with sedimentary country rocks (McLeod, 1990).

Geochemical analyses indicate that this granite is post-collisional, while lead isotopic signatures suggest an upper crustal radiogenic source typical of Avalonian rocks (McLeod, 1990). Gravity modelling indicates that this intrusion is 7.6 km thick in the west and shallows to a thickness of 4 km towards the east (Thomas and Willis, 1989). The inferred temperature of crystallization is between 750° and 680° at 200 and 300 MPa at a relatively high $P(H_2O)$ compared to the higher level (<100 MPa) intrusions of the Pomeroy Intrusive Suite located to the north (McLeod, 1990). Numerous gold occurrences have been reported to occur in the vicinity of the Saint George Batholith that are thought to be related to these Devonian intrusions (Ruitenberg, 1967; Ruitenberg and Fyffe, 1982; McLeod and McCutcheon, 2000). Northeast of Clarence Stream, McLeod (1990) documented gold-bearing quartz veins related to the intrusion.

Granitic dykelets exposed within trenches and outcrops at the East Zone grade laterally into gold- and sulphide-bearing quartz veins. A detailed study of these aplitic to granophyric, weakly metaluminous to peraluminous dykes revealed that they are late fractionates of the Magaguadavic Granite (Thorne et al., 2002). U-Th-Pb geochemical microprobe dating of monazite obtained from these dykes yielded an age of 390 ± 8 Ma (Thorne et al., 2002).

Structure and Metamorphism

Shearing of the Waweig Formation subparallel to the local steepened lithologic layering began prior to the emplacement of the East Branch Brook metagabbroic dykes. During faulting and local extension, the mantle-derived mafic dykes were emplaced into the transpressional to transtensional shear zone as a series of at least three magmatic pulses. These dykes were deformed during their emplacement by synchronous dextral movement along the shear zone (Park, 2001). Hydrothermal alteration of the entire rock package is represented by pervasive hydrothermal biotite, as well as actinolite and muscovite, resulting from the intrusion of the first phase of the Magaguadavic Granite, which is also concurrent with dextral strike-slip movement along the shear zone. A first generation of mineralized quartz veins precipitated from the magmatic hydrothermal fluids in dilatant areas that developed as a result of competency contrast, particularly near lithological contacts. Further reactivation of the shear zone during a protracted history of magmatism and associated alteration caused brecciation, recrystallization, and boudinage of early quartz veins, and development of a new generation of auriferous veins as well as local cataclasite and pseudotachylite (Park, 2003) during fluctuations between brittle and ductile deformation episodes in an overall ductile regime. Uplift of the batholith that caused dip slip movement along the shear zone is represented by a down-dip lineation defined by parallel alignment of cordierite porphyroblasts and volcanic lapilli. This movement overprinted the earlier episodes of strike-slip deformation and rotated and/or dismembered the quartz veins vertically resulting in the net easterly plunge of the mineralized bodies (Park, 2001). The latest granitic pegmatite to aplitic dykes and associated auriferous quartz veins were emplaced relatively late in the history of the shear zone (390 ± 8 Ma; Thorne et al., 2002) with minor dextral strike slip movement occurring subsequent to their emplacement.

The rocks hosting the Clarence Stream deposit exhibit differential shear fabric features as a function of heterogeneous deformation (Park, 2003), that range from a northeast-trending penetrative foliation to local mylonite, pseudotachylite and cataclasite. These fabrics were generated during a protracted history of shear zone reactivation coupled with vein formation and dyke emplacement. Hydrothermal alteration of the entire rock package at Clarence Stream is represented by pervasive high-temperature biotite alteration associated with the episodic emplacement of the various phases of the Magaguadavic Granite. Competency contrast and degree of hydrothermal alteration within the host rocks were major factors in controlling brittle-ductile behaviour and the localization of dilatant zones in the shear system; this inturn affected fluid movement and distribution of mineralization.

Mineralization

A strong Au-As-Sb association characterizes the mineral assemblage at the Clarence Stream deposit. It is represented by an arsenopyrite, pyrrhotite, and berthierite sulphide assemblage that is associated with free gold. A variety of Sb-bearing minerals identified by Louis Cabri occur in the veins including stibnite, aurostibite, gudmundite, and native antimony (Freewest Resources, June 28, 2001, press release). Silver, Bi, Cd, Te, S, and Cu were also found to have a positive correlation with gold mineralization. This signature closely resembles the documented geochemical signature of intrusion-related gold deposits described by Thompson et al. (1999), Lang et al. (2000), Thompson and Newberry (2000), and Lang and Baker (2001), which is the exploration model used by Freewest Resources.

Two major zones of mineralization have been delineated on the property based on the location of geochemical soil anomalies and contrasting host rock lithologies. Mineralization is

better preserved in larger quartz veins that were shielded by the more competent metagabbroic bodies at the West Zone (Fig. 4) whereas boudinaged quartz veins hosted within fissile metasedimentary units at the East Zone (Fig. 5) are more deformed and therefore, less continuous. These quartz veins exhibit textures that range from mylonitic to brecciated formed during episodic deformation, with late development of an annealed saccharoidal texture as a result of thermally induced recrystallization of strained quartz.

Grab samples up to 574 g/t Au have been obtained from the mineralized quartz veins at the East Zone. Petrographic examination revealed that the gold mineralization consists of aurostibite and discrete grains of native gold associated with arsenopyrite, pyrrhotite, berthierite, chalcopyrite, stibnite and native antimony. Secondary Ion Mass Spectrometry (SIMS) of pyrite and zoned arsenopyrite crystals conducted by Louis Cabri indicated that refractory gold is a relatively minor component of the gold mineralization at Clarence Stream.

Disseminated mineralization also occurs within the host rocks, with the higher values being contained within the metagabbroic host rocks. These metagabbroic rocks have returned values up to 12 g/t Au over 0.5 m. It is likely that the iron in these rocks acted as a chemical trap for the gold mineralization during fluid-wall rock reactions.

Geochemical, isotopic, and geochronologic studies indicate that the Clarence Stream deposit has an intrusion-related origin for the gold mineralization (Thorne et al., 2002; Thorne and Lentz, 2003). These studies have established a spatial and temporal genetic link between the I-type Early Devonian Magaguadavic Granite and the gold mineralization. The incorporation of abundant metal-rich metasedimentary material likely was responsible for late reduction of the otherwise oxidized Magaguadavic Granite, which provided favourable conditions for the gold to be concentrated into the hydrothermal fluids that evolved during the magmatic-hydrothermal transition.

Acknowlegdments

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Stops

Stop 1A – Trench 1 (West Zone – Main Zone of the Clarence Stream gold deposit)

Figure 6 shows a plan view of the western portion of Trench 1. It consists of a quartz vein (up to 3 m wide) that occupies a dilatant zone at the contact between a fine- to medium-grained grey-green metagabbroic dyke of the East Branch Brook suite and a metasedimentary unit of the Waweig Formation. A small granitic dyke (up to 10 cm wide) on the north side of the larger quartz vein can be seen in the central portion of the trench. A quartz mylonite in the bottom portion of the trench is overprinted by a C-S fabric and is crosscut discordantly by a cataclastic unit containing pseudotachylite comprised of angular mylonitic fragments suspended in an

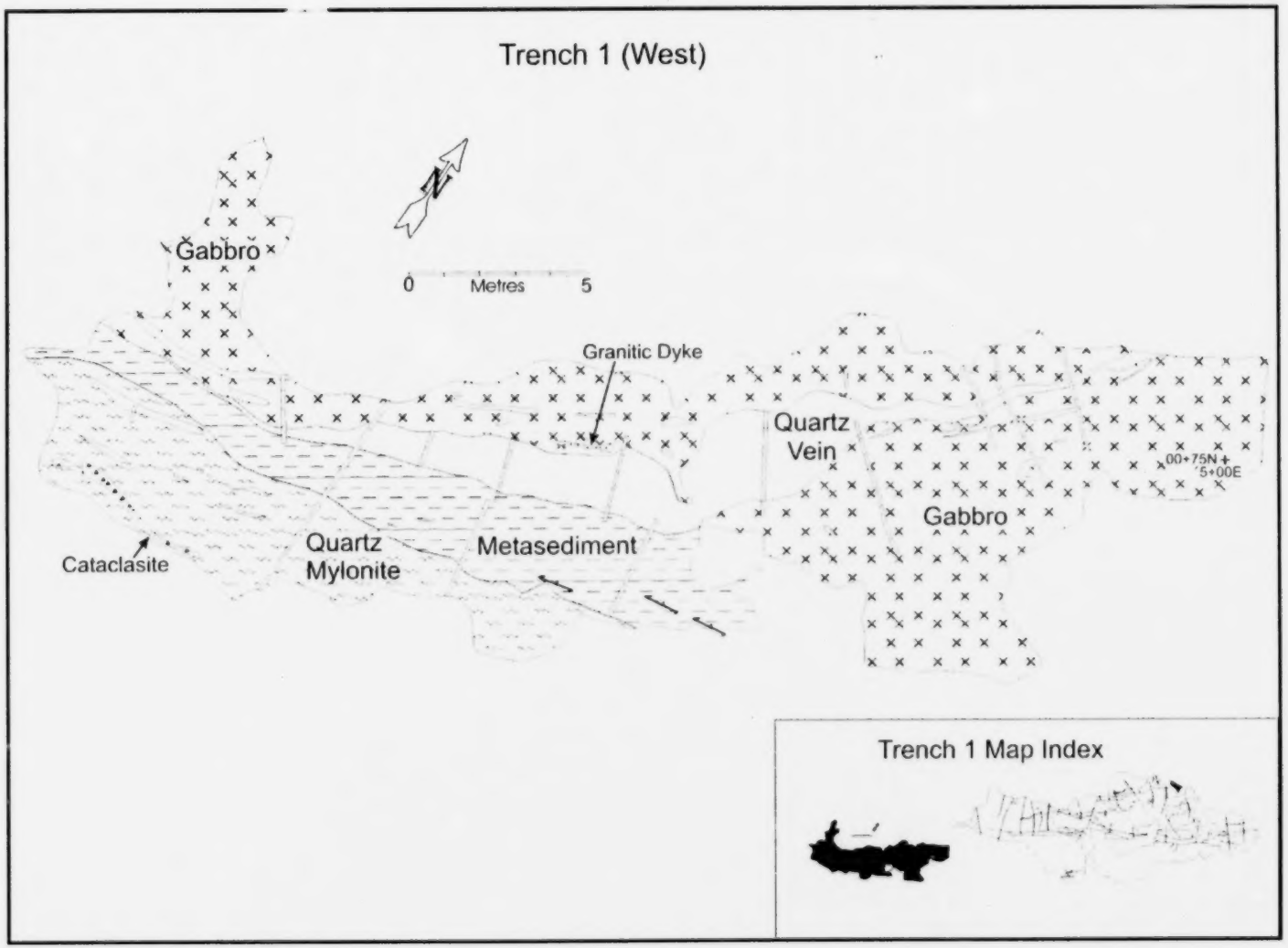

Figure 6. Plan view of the western portion of Trench 1.

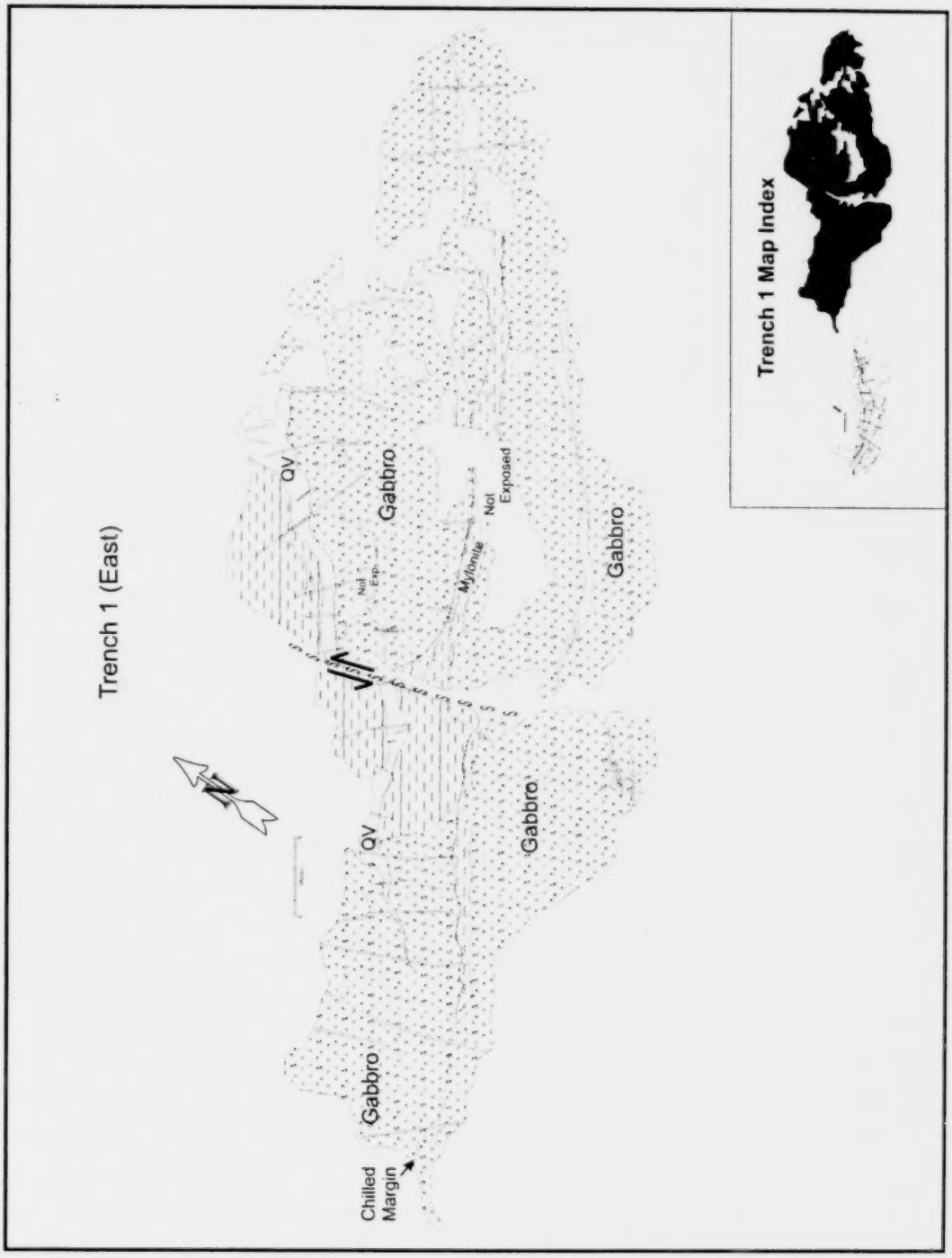

Figure 7. Plan map of the eastern portion of Trench 1.

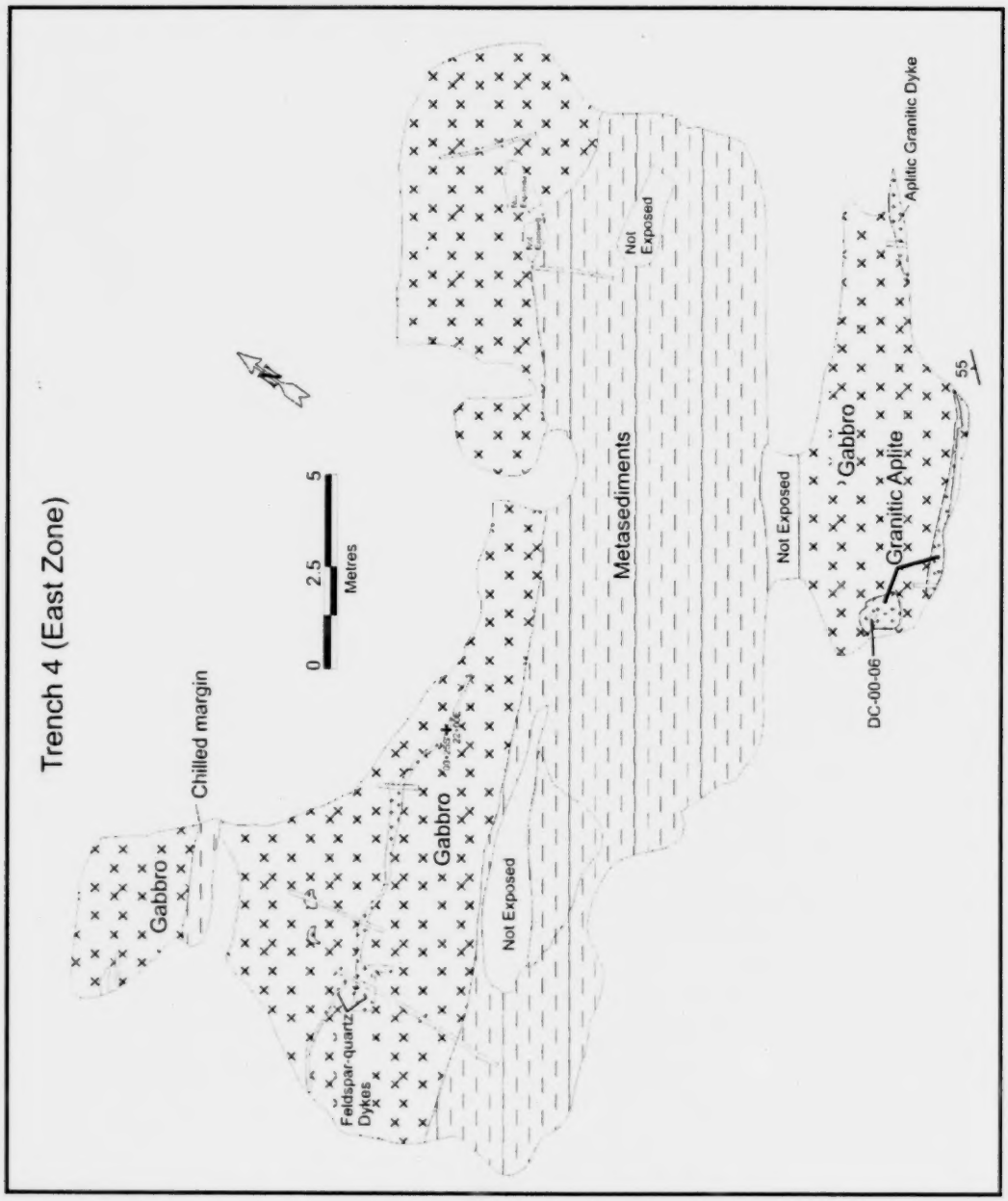

Figure 8. Plan view of trench 4 (East Zone).

epidote-rich matrix. Heterogeneous deformation is evident by the contrast in fabric development amongst the various units of differing competency in this trench. The main vein in this trench contains arsenopyrite, pyrite, sphalerite, berthierite, chalcopyrite, and visible gold. Channel sampling of the vein returned values of 68.1 g/t Au over 3 m and 72.1 g/t Au over 3 m.

Stop 1B – Trench 1 (West Zone – Main Zone of the Clarence Stream gold deposit)

Figure 7 shows the plan view of eastern portion of Trench 1. This trench consists of a series of parallel northeast-trending quartz veins of variable generations that vary in width, texture, sulphide content and colour. Narrower veins that contain less mineralization crosscut the metagabbro bodies, whereas a larger vein containing significant gold mineralization (up to 23.7 g/t Au over 1 metre) occupies the contact between the foliated metagabbro and cordierite-biotite-muscovite-bearing metasedimentary units. A chilled margin between two phases of metagabbro can be seen in the west end of this trench. The south end of the trench consists of the older, lighter coloured metagabbro, whereas the younger, more altered looking metagabbro unit occupies the northern portion of the trench. Channel sampling of the altered metagabbro returned values up to 12 g/t Au as disseminated mineralization. The trench is cut be a post-mineralization, northwest-trending fault zone (D_4) that displaces the units by 4.5 metres in a sinistral fashion.

Stop 2 – Trench 4 (East Zone – Main Zone of the Clarence Stream Gold deposit)

The plan view of this trench is shown in Figure 8. At this location, thin, interbedded fine-grained metasediments and medium- to coarse-grained metagabbros are cross-cut by pegmatite-aplite dykes. The texture of the granitic dykes varies from aplitic to granophyric to pegmatitic and they are seen to grade laterally into gold-sulphide-bearing quartz veins. Anomalous gold values were obtained within these dykes and are thus far, the best evidence supporting the intrusion-related origin for gold mineralization. Geochemical analysis of these veins indicate that they are late fractionates of the Magaguadavic Granite and U-Th-Pb dating of monazite indicates that they are 390 ± 8 Ma (Thorne et al., 2002). These dykes intrude late in the history of the shear zone, are transposed parallel to the foliation, and are pulled apart parallel to the foliation. The metasedimentary units at this location are extremely deformed as indicated by the presence of asymmetric boudinage of the more competent layers during dextral deformation.

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Kedron Gold Occurrence, northern Saint George Batholith, southwestern New Brunswick

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Introduction

The Kedron occurrence consists of gold mineralization associated with an endogranitic tin lode deposit within the Kedron Granite located along the northwestern margin of the Saint George Batholith. This is the only known occurrence of this type and little is known about the controls on mineralization due to limited work and poor exposure.

Exploration History

Extensive exploration for tin mineralization in the Kedron Stream area was conducted by MEX Exploration and Billiton in the early 1980's. The cupola of the Kedron granite (also referred to in the literature as the Bonny River Granite) was discovered during exploration and was found to have associated tin mineralization. Billiton (unpublished information) drilled seven holes in 1984 near trenched exposures of the Kedron Granite. Only one section of core was analyzed for gold and since that time, there has been little in the way of gold exploration conducted in the area.

Regional and Local Geological Setting

The Kedron Granite is a small cupola (100 metres in diameter; Taylor et al., 1985) that intrudes Silurian sedimentary sequences (Fig. 1) along the northwestern margin of the Saint George Batholith. In particular, it intrudes the Sand Brook Formation which consists of green to grey, locally calcareous feldspathic wacke, siltstone and pelite in that area (Fyffe, 1992).

The Kedron Granite has been described by Taylor (1992) as a lithian mica-topaz-bearing fine to medium-grained granite with an equigranular to seriate texture which is similar to the Pleasant Ridge Granite. It is weakly peraluminous, fluorine-rich and has low concentrations of TiO_2, MgO, CaO and P_2O_5 relative to other types of granites (Taylor, 1992). There are tin-tungsten-bearing veins, lodes and associated greisen alteration associated with this pluton (Taylor, 1992).

$^{40}Ar/^{39}Ar$ dating of the Kedron Granite yielded a preliminary age of 362 Ma which is similar in age to the Pleasant Ridge Granite (361 Ma, $^{40}Ar/^{39}Ar$; Taylor, 1992). At the surface exposure, the Kedron Granite is mostly aplitic, is intensely silicified and contains significant quantities of topaz and fluorite (Taylor et al., 1985). Beneath the silicified zone are zones of pegmatite that

KEDRON GOLD (ENDOGRANITIC LODE: MOUNT PLEASANT-STYLE)
LEGEND
LATE DEVONIAN
KEDRON GRANITE: Grey equigranular muscovite-biotite granite.
SILURIAN
FLUME RIDGE FM.: Green to grey, calcareous feldspathic wacke and noncalcareous shale
SAND BROOK FM.: Green to grey, locally calcareous feldspathic wacke, siltstone and pelite
DIGGEGUASH FM.: Grey lithic and feldspathic wacke, siltstone and shale
1 km

Figure 1. General geology and location of Billiton's drill holes at the Kedron gold occurrence (modified after McLeod, 1990 and Fyffe, 1992).

KEDRON GOLD (ENDOGRANITIC LODE: MOUNT PLEASANT-STYLE)
BR-84-1
BR-84-2
GOLD INTERSECTION
0.4 g/t Au over 3m
with 0.27 % Sn, 0.55 % Cu
and 1.75 % Zn
SYMBOLS
LEGEND
LATE DEVONIAN
DKd KEDRON GRANITE: Grey equigranular muscovite-biotite granite.
SILURIAN
SfRmc FLUME RIDGE FM.: Green to grey, calcareous feldspathic wacke and noncalcareous shale
SSbmc SAND BROOK FM.: Green to grey, locally calcareous feldspathic wacke, siltstone and pelite
SDmc DIGDEGUASH FM.: Grey lithic and feldspathic wacke, siltstone and shale
1 Km

Figure 1. General geology and location of Billiton's drill holes at the Kedron gold occurrence (modified after McLeod, 1990 and Fyffe, 1992).

are underlain by quartz-topaz-lithian mica-fluorite greisen (Taylor et al., 1985). Within one of these pegmatitic zones, a sulphide-rich, chloritic section was intersected in drilling. This is identical to the replacement-type tin lodes that occur within the nearby Mount Pleasant deposit (e.g., Kooiman et al., 1986). Unaltered granite occurs beneath the greisen zone at a depth of approximately 100 metres (Taylor et al., 1985).

Mineralization

Prior to the recent interest in intrusion-related gold deposits, the only commodity of significance in this particular endogranitic environment was tin. Tin mineralization occurs within the silica-rich and pegmatitic zones and ran up to 300 ppm Sn (Taylor et al., 1985). Analyses of the greisen zone indicated that it was also elevated in Sn (500 to 2000 ppm Sn; Taylor et al., 1985). One vein containing arsenopyrite, pyrite, chalcopyrite, molybdenite, and cassiterite also contained elevated gold and silver values as well (Taylor et al., 1985). Mineralization was intersected in a hole drilled through the Kedron pluton by Billiton in 1984 (see Fig. 2). The gold intersection considered here ran 0.4 g/t Au over 3 metres with 0.27% Sn, 0.55% Cu, and 1.75% Zn (Billiton, unpublished information). Although low grade, the presence of gold associated with the Late Devonian tin granites may be of great significance regionally.

Stops

Drill core from this occurrence will be available for examination at the former Mount Pleasant mine site.

Acknowledgments

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Golden Ridge / Poplar Mountain Gold Deposit, southwestern New Brunswick, Canada and eastern Maine, USA

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**Much of this data has been taken from a summary report on the Poplar Mountain deposit which was prepared by Freewest Resources Canada Incorporated, August 1998 and Chi and Watters (2003).*

Introduction

The Golden Ridge gold deposit (also known as the Poplar Mountain property) held by Freewest Resources Canada Incorporated, is located along the New Brunswick – Maine, USA border. It is located approximately 80 km west of Fredericton and 40 km south-southwest of Woodstock, New Brunswick. This deposit is characterized by low grade gold mineralization disseminated throughout a dacitic subvolcanic intrusion situated between the Woodstock and Meductic faults.

Exploration History

Prior to exploration by Freewest Resources Canada Incorporated, there was very little precious metal exploration in the vicinity of the Golden Ridge deposit. Exploration conducted in the area for porphyry copper deposits documented weakly anomalous gold mineralization within the Ordovician hornblende granodiorite at Connell Mountain where samples yielded values up to 1.3 g/t Au over 1.3 m from a gossan – quartz vein zone (Ruitenberg et al., 1990).

In 1992, the New Brunswick Department of Natural Resources and Energy conducted a glacial till mapping and sampling survey which outlined a broad Au, As, Sb, and Hg till anomaly near the New Brunswick-Maine border centered along the Monument Brook area (Seaman, 1993; 1994). Prospector Don Ward followed up on this survey and conducted B and C horizon soil surveys which were successful at duplicating and further refining the anomalous zones.

Freewest Resources Canada Incorporated proceeded to option the property from Mr. Ward. Follow up prospecting discovered intensely sericitized and carbonatized andesite porphyry where mineralization was contained within quartz-cemented breccia and quartz vein stockwork which ran up to 7.5 g/t Au (Freewest, 1998).

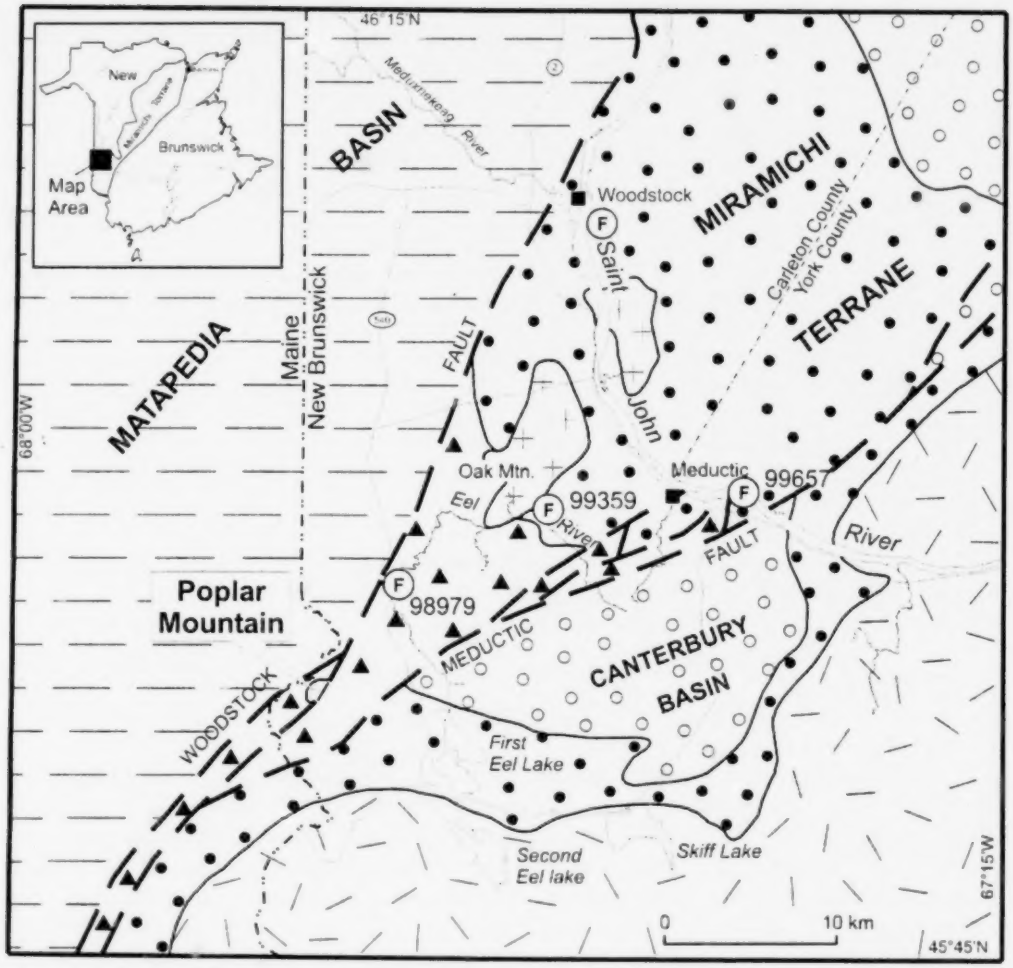

Figure 1. Geology of the Poplar Mountain area (modified after Fyffe, 2001).

In 1997 and 1998, Freewest followed up on these finds and completed an airborne geophysical survey, linecutting, ground geophysical surveys, geochemical surveys, prospecting and geological mapping in the Poplar Mountain region. Exploration activities were focused along the 1.4 km long Au-As-Sb soil anomaly. Through their exploration efforts, they uncovered 12 gold discoveries in outcrop along with several angular boulders that contained high-grade antimony mineralization that ran up to 25% Sb (Freewest Resources, 1998). In addition to this, high-grade banded, massive sulphide float was discovered as boulders that assayed up to 8.4 g/t Au, 224 g/t Ag, 15.6% Pb and 20.9% Zn (Freewest Resources, 1998).

A drill program was completed during the 1999 field season to test the extent of the mineralization in three separate target areas. At the first target, a broad mineralized deformation zone up to 60 metres wide was intersected in the drill holes (Freewest Resources, 1999). This area returned intersections that ran 1.34 g/t Au over 14.7 metres, 1.13 g/t Au over 23.0 metres, 1.47 g/t Au over 15.7 metres and 2.50 g/t Au over 13.4 metres (Freewest Resources, 1999). The second target area had a similar mineralized structure that gave values of 0.84 g/t Au over 23.7 metres and 0.58 g/t Au over 11.9 metres (Freewest Resources, 1999). Drilling at the third target

area intersected 12.8 metres of 0.75 g/t Au as well as 0.42 g/t Au over 10.2 metres and 1.10 g/t Au over 6.6 metres (Freewest Resources, 1999).

Freewest's attention shifted away from the Golden Ridge property as a result of their success with the Clarence Stream gold deposit further to the south. Recently, Freewest Resources Canada Incorporated has signed an option agreement with First Narrows Resources Corporation of Vancouver, B.C. for the Golden Ridge property.

Regional Geological Setting

The Golden Ridge gold discovery is underlain by rocks that belong to the Miramichi terrane that include the Woodstock and Meductic groups in New Brunswick and adjacent Maine (Fyffe and Fricker, 1987; Fyffe, 2001). Overall, two major faults occur in close proximity to the Poplar Mountain occurrence. They are the NE to ENE-trending Woodstock and Meductic faults. The Meductic Fault has been described by Lutes (1979) as a steep fault that is downthrown on the south side whereas the Woodstock Fault has been interpreted as a crustal-scale structure that separates the Miramichi Terrane from the Matapedia sequence in that area (Fyffe and Fricker, 1987).

The Cambro-Ordovician Woodstock Group and the Ordovician Meductic Group are the predominant lithologies in the Golden Ridge area (Fyffe, 2001; Fig. 1). As described by Fyffe (2001), the Woodstock Group is mainly a succession of interbedded grey to green quartzite, quartz wacke, and shale overlain by black mudstone and shale. The base of the Meductic Group consists of a sequence of felsic and minor intermediate flows and volcanic breccia. This sequence is overlain by a series of intermediate volcaniclastic rocks and ferro-manganiferous mudstone that is overlain by mafic volcanics. The top of the group is dominated by feldspathic wacke and black shale.

The Matapedia basin which lies immediately north of the Woodstock Fault, consists of Late Ordovician to Silurian, argillaceous carbonate rocks and siliciclastic turbidites. The Canterbury basin lies to the south across the Meductic Fault and contains conglomerate, limestone and volcanic rocks of Siluro-Devonian age (Fyffe, 2001).

The Siluro-Devonian Skiff Lake granitic phase of the Pokiok batholith intrudes the sequence further to the south (Lutes, 1979). This grey porphyritic muscovite, biotite-bearing granite has been dated by Bevier (1989) at an age of 409 Ma.

Local Geology

Much of the mineralization is hosted within an elliptical-shaped, intermediate to mafic subvolcanic intrusion referred to as the Poplar Mountain Volcanic Complex by Chi and Watters (2002). It forms a topographic high known as Poplar Mountain near Monument Brook. The extremities of this intrusion are thought to be represented by a 4 km long magnetic anomaly, which was defined by a total field magnetic airborne geophysical survey (Freewest Resources, 1998). In general, the deposit is mainly hosted by a highly altered porphyritic dacitic intrusion and surrounding volcaniclastic rocks, which are interpreted to represent a volcanic dome overlain by mineralized basaltic volcanics. Detailed descriptions are provided by Leitch (1997) and Chi and Watters (2002).

The age of the volcanic complex remains in question. Although stratigraphic evidence indicates an Ordovician age, U-Pb dating is still inconclusive and indicates that it could also be as young as Middle Devonian (William Davis, personal communication).

Mineralization

The first descriptions of mineralization at the Golden Ridge deposit were provided by Freewest Resources Incorporated (1998) and Watters (1999). The following descriptions are taken from their work.

Gold mineralization at Golden Ridge is closely associated with sericite-carbonate-albite-sulphide alteration within the dacitic to andesitic intrusion (Freewest Resources, 1998; Watters, 1999). Gold is found within the intrusion and also within quartz veins and quartz-cemented breccias within and along the margin of the intrusion (Freewest Resources, 1998). The mineralized quartz exhibits multiphase drusy and cockscomb textures that are indicative of an epithermal type system. A close association of the gold mineralization with acicular arsenopyrite crystals has been noted both within the intrusion and the breccia zones (Freewest Resources, 1998). The gold mineralization and phyllic alteration appears to be controlled mainly by a NNW-trending sinistral fault and an E-W-trending set of faults that may be second order splays to the nearby first order Woodstock Fault (Freewest Resources, 1998). Sampling has revealed that there is a strong correlation between Au, As and Sb (Freewest Resources, 1998). There are two types of alteration of the rocks surrounding the mineralized veins (Watters, 1999). The first type that does not appear to be associated with gold mineralization is propylitic alteration characterized by chlorite, calcite, epidote, albite, quartz and opaques (Watters, 1999). However, the gold mineralization is seen to be associated with rocks that exhibit light buff or light green phyllic alteration consisting of sericite, carbonate, albite, pyrite, arsenopyrite and rutile (Watters, 1999).

Further detailed descriptions of the mineralization are provided by Chi and Watters (2002). Participants are encouraged to refer to this publication fro up to date details of the deposit.

Genetic Model

From their exploration activities, Freewest Resources (1998) concluded that the Woodstock Fault and the related second order structures played an important role in creating permeability and dilatancy in the hosting intrusive-volcanic complex. The presence of this complex provided favourable rheological and chemical conditions for the deposition of the gold mineralization in an epithermal setting (Freewest Resources, 1998). According to Chi and Watters (2002), the mineralizing system has some characteristics indicative of low sulphidation epithermal deposits or to the outer parts of porphyry systems.

Acknowledgments

We would like to thank Freewest Resources for providing us with core for field trip purposes.

Stops

Mineralized drill core from this deposit with be examined at the former Mount Pleasant mine site.

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McDougall Brook Gold Occurrence, Mount Pleasant Caldera, southwestern New Brunswick

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Introduction

Exploration within the Mount Pleasant Caldera in the early 1980's was focused mainly on tin and tungsten mineralization associated with the younger, more highly evolved granitic phases of the Saint George Batholith. The recent association between the Magaguadavic Granite and gold mineralization (i.e., Clarence Stream gold deposit) has lead many to believe that gold mineralization may only be associated with this one particular phase of the Saint George Batholith. Although low grade, the discovery of gold mineralization associated with the younger Seelys Formation discounts this theory and may broaden the gold potential in the area to include the younger, more highly evolved granitic phases of the Saint George Batholith as well.

Exploration History

Gold mineralization near the margin of the McDougall Brook microgranite was discovered in 2-3 m square brecciated boulders of the Seelys Formation by Reg Cox Jr. in 1995 (Cox, 1997). Previous exploration in the area was conducted mainly by Billiton Canada Ltd. who did not analyze their samples for gold in their search for tin and tungsten mineralization. Boulders of hydrothermal breccia up to 2 m wide were found by Mr. Cox along a logging road near the margin of the McDougall Brook granite. When analyzed, they were consistently found to contain on average 200-500 ppb Au (Cox, 1997).

Regional Geological Setting

The McDougall Brook gold showing is located within the Upper Devonian Mount Pleasant Caldera (see Fig. 1 – Introduction) that hosts the past producing Mount Pleasant mine, famous for its tin-tungsten-molybdenum mineralization. The caldera, which is approximately 13 by 34 km, is bounded to the east and west by polydeformed Ordovician to Silurian turbiditic metasedimentary rocks of the Digdeguash and Flume Ridge formations (McCutcheon et al., 2001). Along the southern margin of the caldera are the Late Silurian to Devonian granitic rocks of the Saint George Bathlolith (McCutcheon et al., 2001). Rocks of the Upper Devonian Piskahegan Group are contained within the caldera and are further divided into exocaldera, intracaldera, and late caldera-fill sequences (McCutcheon, 1990; McCutcheon et al., 1997). Since the McDougall Brook showing is associated with rocks that comprise the Intracaldera Sequence, the rocks that comprise the exocaldera and intracaldera will not be further discussed here and for a more detailed description, readers are referred to McCutcheon et al. (1997).

The Intracaldera Sequence consists of the Scoullar Mountain Formation, Little Mount Pleasant Formation, Seelys Formation and McDougall Brook Porphyritic Microgranite, given in their stratigraphic order (McCutcheon et al., 1997; 2001). Also intruding the Scoullar Mountain Formation are a number of unnamed felsic dykes and a mafic dyke that intrudes the Little Mount Pleasant Formation (McCutcheon et al., 1997; 2001).

Rocks that comprise the Scoullar Mountain Formation include sedimentary breccia, interbedded andesitic lava, felsic pyroclastic rocks and a minor sandstone-conglomerate unit (McCutcheon et al., 1997; 2001). The Little Mount Pleasant Tuff consists of two crystal tuff units and a flow-banded rhyolite (McCutcheon et al., 1997; 2001).

Overlying the Little Mount Pleasant Tuff is the Seelys Formation that consists of lithic tuffs and pumice-bearing lithic lapilli-tuffs as well as banded, pumiceous, crystal tuff, and densely welded crystal tuff (McCutcheon et al., 1997; 2001). Fragments of the Scoullar Mountain andesite and Little Mount Pleasant rhyolite are found within the basal unit of the Seelys Formation (McCutcheon et al., 1997; 2001). The McDougall Brook gold showing is hosted within hydrothermally brecciated rocks of the Seelys Formation (Fig. 1).

In general, the McDougall Brook Porphyritic Microgranite is comprised mainly of porphyritic monzogranite. However, in the vicinity of the McDougall Brook gold showing, the rocks consist of a marginal phase of feldspar (± quartz) porphyry and minor fine-grained quartz monzonite (McCutcheon et al., 1997; 2001).

Mineralization

The host rocks to the mineralization consist of intensely greisenized hydrothermal breccias developed in rocks of Seelys Formation adjacent to the McDougall Brook Porphyritic Microgranite. These breccias have been found as boulders up to 2 m wide in a 0.5 km wide zone that extends 2 km along a logging road. Outcrops on either side of the road are also intensely brecciated and, a few breccia veins are contained in the microgranite as well. Gold tends to be concentrated in samples that contain minor sulphides in light green quartz breccia with reddish staining (Cox, 1997), although samples with no obvious sulphides were also anomalous. Samples that contained the highest gold values were also elevated in Fe, As and Ag. The sample that contained the most gold ran 1.05 g/t Au (Cox, 1997).

In a few of the meager outcrops of microgranite in this area, sulphide-rich veinlets occur along northwest-trending fractures. This orientation is consistent with minor late faults that occur along the eastern margin of the caldera. The role of these structures relative to breccia emplacement and mineralization is unknown, but may be significant.

To date, there has been minimal exploration work conducted at this showing. Further research is being conducted by researchers at the University of New Brunswick as a part of an ongoing Targeted Initiative Geoscience project funded by the Geological Survey of Canada and NSERC (grant to D. Lentz) in collaboration with Freewest Resources Canada Incorporated and the New Brunswick Department of Natural Resources and Energy.

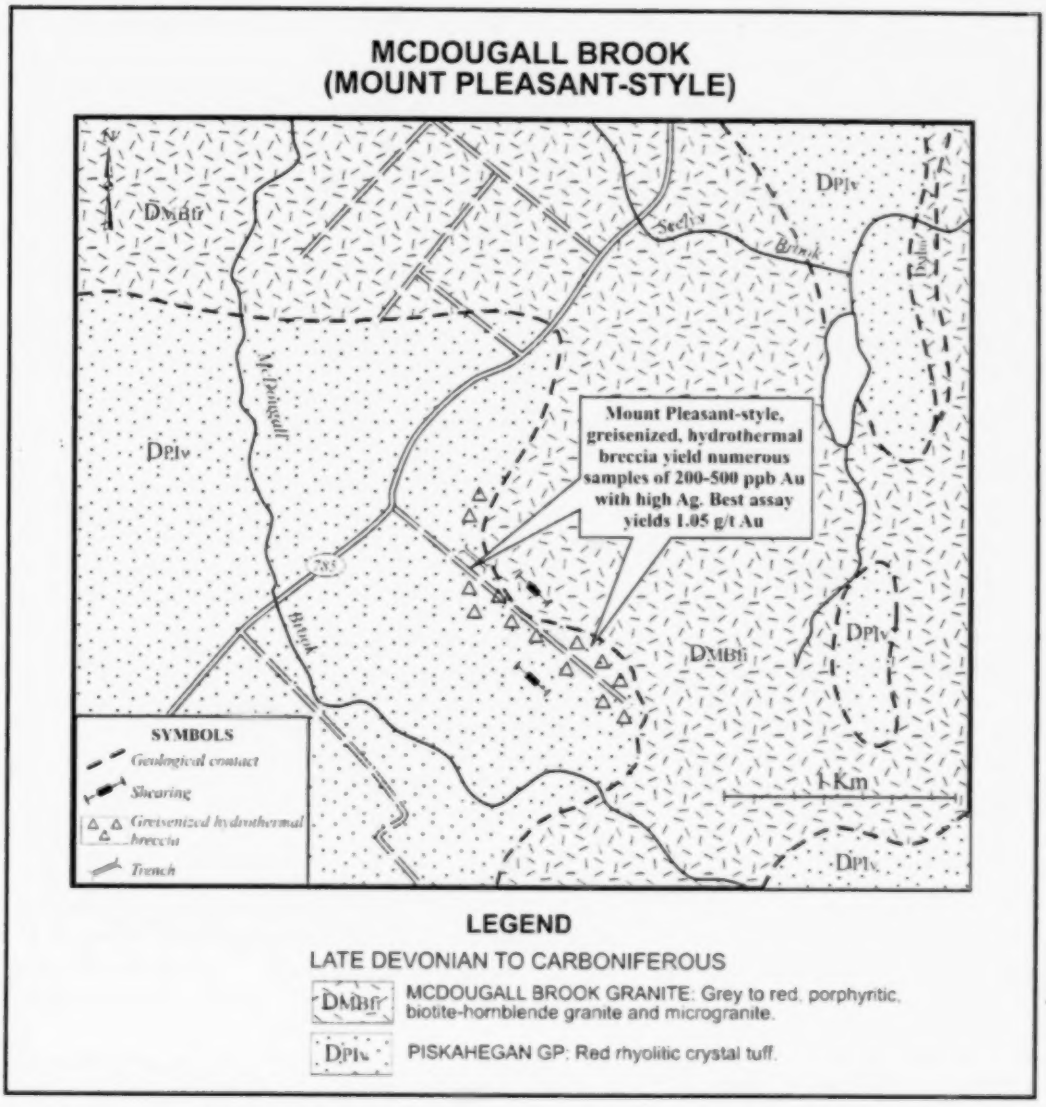

Figure 1. Local geology of the McDougall Brook showing (modified after McCutcheon, 1990).

Acknowledgments

Maurice Mazzerolle and Terry Leonard prepared the figure.

Stops

Stop 1 – Hydrothermal breccia boulders – McDougall Brook gold showing

Several large angular boulders of hydrothermal breccia lie along side the logging road. The highest gold values tend to be typical of those boulders that contain red hematite staining. Only minor amounts of mineralization are visible within these boulders.

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Mineralization at Anomaly A, Clarence Stream Gold Deposit, southwestern New Brunswick

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**This contribution contains excerpts taken from Thorne et al. (2002)*

Introduction

Mineralization at the Anomaly A portion of the Clarence Stream deposit was discovered during expansion of the original grid to the west and northwest by Freewest Resources in their search for additional mineralized zones outside the Main Zone area. Concurrent geological mapping, prospecting and soil sampling programs were conducted on this new grid and they were successful at delineating a number of target areas along the northern side of the Sawyer Brook Fault within the polydeformed, clastic rocks of the Ordovician Kendall Mountain Formation (Fig. 1). From east to west, these zones are the Murphy, MW and AD zones. Mineralized boulders have been discovered near the AD Zone that contained up to 418 g/t Au. The geometry of these mineralized zones is complicated by a complex structural history that affected the region.

Exploration History

A northwest striking multi-element (Au-As-Sb) soil anomaly approximately 2.5 km long with a variable width up to 500 m was identified during concurrent geological mapping, prospecting and B-horizon soil sampling programs conducted during the fall of 2001.

Trenching of the Murphy Zone uncovered polydeformed clastic rocks of the Ordovician Kendall Mountain Formation that were intensely sericitized, silicified and veined by stockwork style mineralization. The Murphy Zone has been exposed over a 400 m strike length and consists of two sets of mineralized quartz veins that contain pyrite, arsenopyrite, stibnite, pyrrhotite, and lesser amounts of sphalerite, chalcopyrite, and locally visible gold (Freewest press release, Apr. 24, 2002). The veins and stockwork are contained within 3 to 10 m thick panels of folded sericitized quartz arenite and mudstone (Freewest press release, Apr. 24, 2002).

Channel sampling of the trenched exposures at the Murphy Zone returned values of 4.81 g/t Au over 5 metres and 3.78 g/t Au over 8.5 m (Robertson, 2002). Drilling of the zone returned assays of:

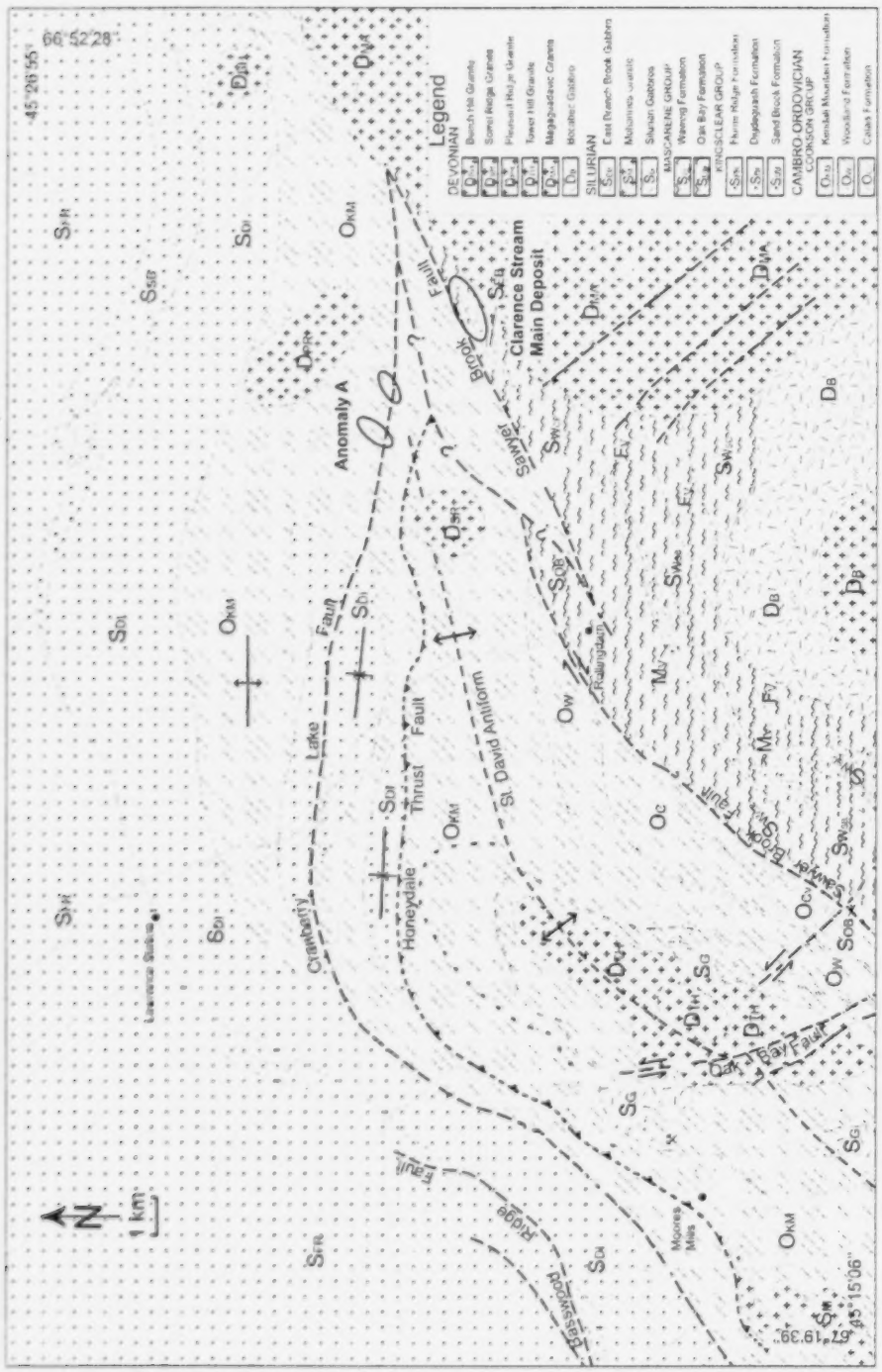

Figure 1. Regional geologic setting of the mineralized zones (outlined in ovals) that comprise the Clarence Stream deposit. Geology modified from Fyffe (1997) and McLeod et al. (1998), and modified from Castonguay et al. (2003).

Drill Hole	Interval (m)	Grade (g/t Au)
CS02-70	9.00	7.33
CS02-77	3.00	8.99
CS02-79	5.50	3.54
CS02-87	3.20	4.42

Prospecting of the AD Zone uncovered grab samples up to 14.9 g/t Au and mineralized boulders from the MW Zone assay up to 10.2 g/t Au (Robertson, 2002). Trenching in the area of these two mineralized zones was next to impossible due to the persistence of swampy conditions and the extreme depth of the overburden. Therefore, these zones were tested by means of a drilling program.

Results from drilling revealed that the AD Zone consisted of structurally controlled shallowly dipping mineralization. As of September 2002, the AD Zone was drilled over a strike length of 300 m and a width of 125 m (Robertson, 2002). The best intercepts (Freewest press release, Sept. 5, 2002) include:

Drill Hole	Interval (m)	Grade (g/t Au)
AD02-13	3.00	6.32
AD02-14	6.73	7.09
AD02-15	8.50	4.31
AD02-16	7.50	6.41
AD02-17	7.95	1.23
AD02-18	3.00	4.17
AD02-19	4.40	4.03

Further drilling at the AD Zone returned values of (Freewest press release, Oct., 17, 2002):

Drill Hole	Interval (m)	Grade (g/t Au)
AD02-21	4.50	4.41
AD02-28	7.50	7.83

During a sixth phase of drilling, additional significantly mineralized zones were discovered including (Freewest press release, January, 14th, 2003):

Drill Hole	Interval (m)	Grade (g/t Au)
AD02-36	6.5	7.94
AD02-46	7.0	6.27

A seventh round of drilling commenced at the end of February, 2003. Highlights of this phase were (Freewest press release, Apr. 4, 2003):

Drill Hole	Interval (m)	Grade (g/t Au)
AD03-49	6.0	5.06
AD03-53	15.25	16.39
AD03-57	6.0	5.76
AD03-65	9.7	3.33
AD03-66	3.0	8.16

In addition to the gold, significant antimony mineralization that is present as massive stibnite veins has breen discovered (up to 23.10 % over 7.25 m in hole AD03-53; Freewest press release, Apr. 4, 2003). A drill-indicated mineral resource at the AD Zone was announced to be 428,764 tonnes grading 4.00 g/t Au and 1.80% Sb (Freewest press release, Feb. 26, 2003).

The MW Zone is characterized by a mineralized zone within sericitized wacke and argillites that strikes northeastward with a shallow dip to the south (Freewest press release, Sept. 5, 2002). Two easterly-plunging shoots have been recognized to date (Freewest press release, Sept. 5, 2002). Drilling of the zone returned values that include (Freewest press release, Sept. 5, 2002):

Drill Hole	Interval (m)	Grade (g/t Au)
MW02-01	11.00	5.21
MW02-08	15.00	11.79
MW02-13	6.00	6.69
MW02-03	7.00	9.00
MW02-16	10.50	15.44

Regional Geological Setting

The Anomaly A area of the Clarence Stream deposit overlies rocks of the Ordovician Cookson Group along the northwestern margin of the Sawyer Brook Fault (Fig. 1). These rocks belong to the St. Croix terrane of the Gander Zone and have experienced various episodes of deformation. Recent detailed structural mapping in the area was conducted by Castonguay et al. (2003) of the Geological Survey of Canada as a part of a Targeted Geoscience Initiative project. Castonguay et al. (2003) distinguished at least four deformation events that broadly corresponded to those defined by Ruitenberg (1967) in an earlier study.

According to Castonguay et al. (2003), D_1 is represented by a composite bedding-parallel slatey cleavage (S_1) that is also seen to be axial-planar to isoclinal intrafolial F_1 folds. D_2 is represented by close to tight NE-plunging F_2 folds that are locally isoclinal near D_2 high-strain zones (Castonguay et al., 2003). S_2 is axial-planar and dips shallowly to the northwest, and varies from a spaced-fracture or dissolution cleavage to a crenulation depending on rock competency, imprint of S_1, and intensity of D_2 (Castonguay et al., 2003). Ruitenberg and Ludman (1978) and Ludman (1991) suggested that the D_1 and D_2 events were part of a protracted compressive stage, which evolved during the northwest-directed thrusting of the St. Croix Terrane onto the Fredericton Belt in Salinian or early Acadian time.

There is a great deal of complexity associated with the third phase of deformation (D_3, Ruitenberg, 1967). S_3 is a steeply dipping fracture to crenulation cleavage that is axial-planar to open to tight F_3 folds that plunge moderately to the east-northeast or southwest (Castonguay et al., 2003). The Sawyer Brook Fault is interpreted to be a late-D_3 dextral strike-slip fault cutting the southeastern limb of the regional scale St. David anitform (see Fig. 1; Castonguay et al., 2003). S_3 dominates the lithologies southeast of the Sawyer Brook Fault, which encompasses those that host the Main Zone of the Clarence Stream deposit.

Megascopically, D_4 is thought to be reflected by deflection of the St. David antiform (from northeast- to east-trending; see Fig. 1; Castonguay et al., 2003). However, the deflection may

have occurred as a result of emplacement of granitic bodies (Ruitenberg, 1967). F_4 folding consists of upright north-northwest-trending chevron folds with gently plunging axes that increase or decrease the dip (or plunge) of pre-existing structures (Castonguay et al., 2003). Castonguay et al. (2003) note that the D_4 structures are geometrically compatible, and possibly coeval with numerous north-northwest-trending late transverse structures (i.e., the Oak Bay Fault with latest movement interpreted to be Early Jurassic in age (Fyffe et al., 1999)). Late kink bands have been considered by Castonguay et al. (2003) to be late D_5 structures.

Local Geological Setting

Clastic sedimentary rocks of the Ordovician Kendall Mountain Formation are the host rocks to the mineralization at the Anomaly A area of the Clarence Stream deposit. They consist of quartz arenites, greywackes and argillites that have been intruded by the Sorrel Ridge Granite to the west and the Pleasant Ridge Granite to the east. The sedimentary units are polydeformed by the deformation events described earlier and are variably altered (argillic, silicic, sericitic) where mineralization occurs.

Rocks that comprise the Kendall Mountain Formation consist of interbedded shale, siltstone, and minor conglomerate as well as minor basaltic flows (Fyffe and Riva, 1990). An Early Carodocian age has been assigned to this unit based on the presence of graptolites within slatey units (Fyffe and Riva, 1990).

The Sorrel Ridge pluton that intrudes the northwestern boundary of the property is a Late Devonian porphyritic granite pluton that belongs to the Pomeroy Intrusive Suite of the Saint George Batholith (McLeod, 1990; (McLeod et al., 1988)). The country rocks into which this pluon is intruded are contact metamorphosed to andalusite-cordierite-grade hornfels (Butt, 1976; Fyffe, 1997). Butt (1976) and Lentz et al. (1988) demonstrated that the Sorrel Ridge Granite is chemically similar to the Beech Hill series that were emplaced at temperatures of 700°C to 750°C at a pressure of 100 ± 50 MPa.

The Pleasant Ridge Granite located to the east-northeast of the mineralized zone, is also a member of the Pomeroy Intrusive Suite (McLeod, 1990). It is chemically similar to the weakly peraluminous Mount Douglas Granite (Lentz et al., 1988; McLeod, 1990) to the east, which is genetically related to the Mount Pleasant and True Hill tin-tungsten-molybdenum-bismuth deposits. The Pleasant Ridge granitic stock has yielded a $^{40}Ar/^{39}Ar$ muscovite age of 361 Ma (Taylor, 1992). It is a high-silica, fluorine-rich, lithian mica-topaz bearing granite that has significant tin-bearing microgranite associated with it (Taylor, 1992). Peripheral mineralized shear zones immediately southeast of the stock contain tin minerals as well as base-metal sulphides, hematite, and magnetite (Ruitenberg and Fyffe, 1982; Taylor, 1992). This highly evolved granite has Sr isotopic signatures that are indicative of minor assimilation of sedimentary crustal material (Butt, 1976; Lentz et al., 1988). Butt (1976) suggested that this pluton was generated from a water-rich magma, thus implying that vast quantities of hydrothermal activity was associated with its emplacement.

The AD Zone at Anomaly A comprises syn-deformational stockwork and sheeted quartz veins contained by a shallow, north-dipping brittle fracture zone within polydeformed wacke-argillite. This zone is relatively near to the surface and is generally found to be less than 50 metres deep. The AD Zone is part of a broader alteration structural envelope that includes the MW Zone, a south-dipping zone of mineralization of similar style located 200 metres north of the

AD Zone. Both zones are distinguished by associated arsenopyrite-pyrrhotite wall rock replacement and may be joined at depth.

Mineralization

Mineralized quartz and quartz veinlets primarily contain pyrrhotite and pyrite with arsenopyrite and stibnite. Gold is mostly in the quartz veins but is also found to be within the altered wallrocks (Watters, 2003). A preliminary mineralogical study of the AD Zone has identified berthierite ($FeSb_2S_4$) and gudmundite (FeSbS) as common sulfide species. Trace to rare minerals include jamesonite ($FePb_4Sb_6S_{14}$), ullmannite (NiSbS), tetrahedrite ($Cu_{12}Sb_4S_{13}$), cobaltite (CoAsS), sphalerite (ZnS), chalcopyrite ($CuFeS_2$), native antimony (Sb) and nisbite ($NiSb_2$) plus native gold (Au) and aurostibite ($AuSb_2$).

Mutiple episodes of veining are evident within the exposures with early veining consisting of white quartz and quartz-chlorite veining (Watters and Castonguay, 2002). Paragenetic studies by Watters and Castonguay (2002) and Watters (2003) determined that sulphides (arsenopyrite, stibnite, and pyrite) and visible gold are associated with clear and white quartz veins that may be of the same generation as the earliest veins. However, it is also seen in fractures of the early quartz and with massive quartz-sulphide veins. The early veins are interpreted to be syn- and post-D_1 (Watters, 2003). Watters (2003) noted that the multiphase, vuggy quartz-sulphide gold-bearing veins are associated with late D_2 high strain zones. Greisen style mineralization with veins containing chlorite, quartz, fluorite, base metals, and carbonate, crosscuts all these earlier episodes of veining and is located vertically beneath a gold mineralized zone (Watters and Castonguay, 2002). This feature is most likely related to the presence of the local felsic intrusions (Watters and Castonguay, 2002) that underlie the area at depth (Thomas and Willis, 1989; King and Barr, in preparation), thus providing an upper time constraint for the gold mineralization (Watters, 2003).

Alteration related to the mineralizing event is present in the wallrocks as an outer greenish-grey, chlorite-rich alteration halo and an inner buff-coloured alteration halo with associated sulphides proximal to the mineralized veins (Watters, 2003). Alteration is characterized by Ti and Al immobility, leaching of Si, Na, Ca, Sr and perhaps Fe and Mg accompanied by the addition of S, As, Sb, and Au (Watters, 2003).

It is suggested that the gold-bearing vein systems seen at Anomaly A could represent distal styles of mineralization associated with intrusion-related gold systems. However, Castonguay et al. (2003) suggest that gold mineralization is no older than the D_2 event which is thought to have occurred before the emplacement of local plutons in the area.

Acknowledgments

Many thanks to Freewest Resources Canada Incorporated for allowing access to their property and information.

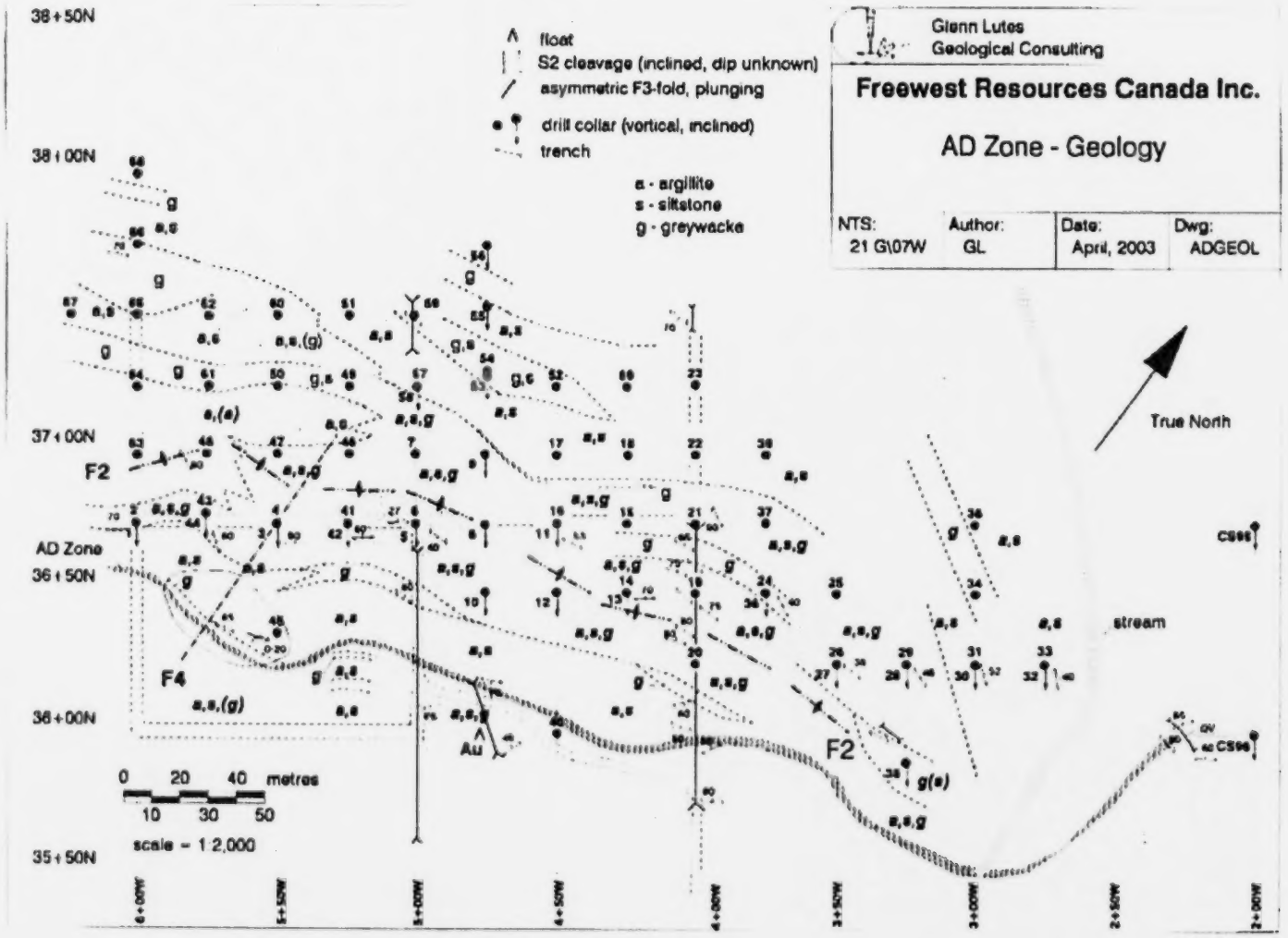

Figure 2. Local geology of the AD Zone. Geology by Lutes (unpublished information).

Stops

Stop 1 - AD Trench (Anomaly A zone of Clarence Stream gold deposit)

The geology of the AD Zone is shown in Fig. 2, which exhibits two styles of mineralization. The first is a main zone of syn-deformational stockwork quartz veins that is contained by a shallow north-dipping brittle-ductile fracture zone within polydeformed greywacke-siltstone-argillite of the Ordovician Kendall Mountain Formation. This zone is associated with pervasive weak to strong argillic to sericitic alteration and arsenopyrite-pyrrhotite replacement, and has been tested over 350 metres strike length by 69 drill holes from 6+25W to 2+75W. It is open both along strike and down dip. A detailed map of the AD Trench is shown in Fig. 3. The second is an irregular zone of vuggy stibnite-rich sheeted quartz veins and veinlets lies above the main zone and is distinguished by only locallized alteration, and lower arsenic-gold content relative to the main zone mineralization. The AD Zone is part of a broader alteration/structural envelope that includes the MW Zone - a south-dipping zone of mineralization of similar style located 200 metres north of the AD Zone. Both zones are distinguished by associated arsenopyrite-pyrrhotite wallrock replacement and may lie within the same structural zone in a synformal structure.

The AD trench has exposed the main zone between L6+00W and L5+50W, which is affected by N-S trending, post-mineralization folds (D_4). The main zone is located along the southern side of the trench with a general trend of 105° and is closely associated with coarser clastic units (greywacke-siltstone) that suggest some control by permeability and porosity in conjunction with structural development. Structural contour maps from drill hole data indicate a general strike of about 070° for the zone. Correlations between drill holes and the surface exposure suggest a dip for the zone of about 25° north in the trench with steeper and shallower dips both down dip and along strike caused by E-W trending folds with subhorizontal hinges (D_3). Plan maps showing the distribution of the gold mineralization at two different levels are shown in Figs. 4 and 5.

Argillite is the dominant lithology in the trenched section and contains a single cleavage that has largely transposed bedding parallel to cleavage (D_2). Greywacke beds have commonly developed an S_2 pressure solution cleavage that refracts to a high angle to bedding. This cleavage dips generally 50-60° north above the zone with substantially shallower dips indicated below the footwall. A structurally modified F_2 isoclinal fold axis lies about 60 metres north of the trench and the trench area lies within the overturned limb of this fold.

The exposed stockwork zone is closely associated with subhorizontal to shallow east-plunging asymmetric kink folds (D_3). Open to tight F_3-folds are most extensively developed in the footwall to the AD Zone and are associated with an irregularly developed S_3 crenulation cleavage with associated secondary micaceous growth.

Interference between F_3 and F_4 fold generations in the trench generate a complex overall structural pattern. Early stages of quartz veining are more strongly deformed and locally form cataclasite within the high strain zone (shear zone). Replacement-style extensional quartz veins peripheral to the zone are developed at a high angle to S_2 cleavage/shearing, most commonly within greywacke units, and often have inherited the S_2 cleavage.

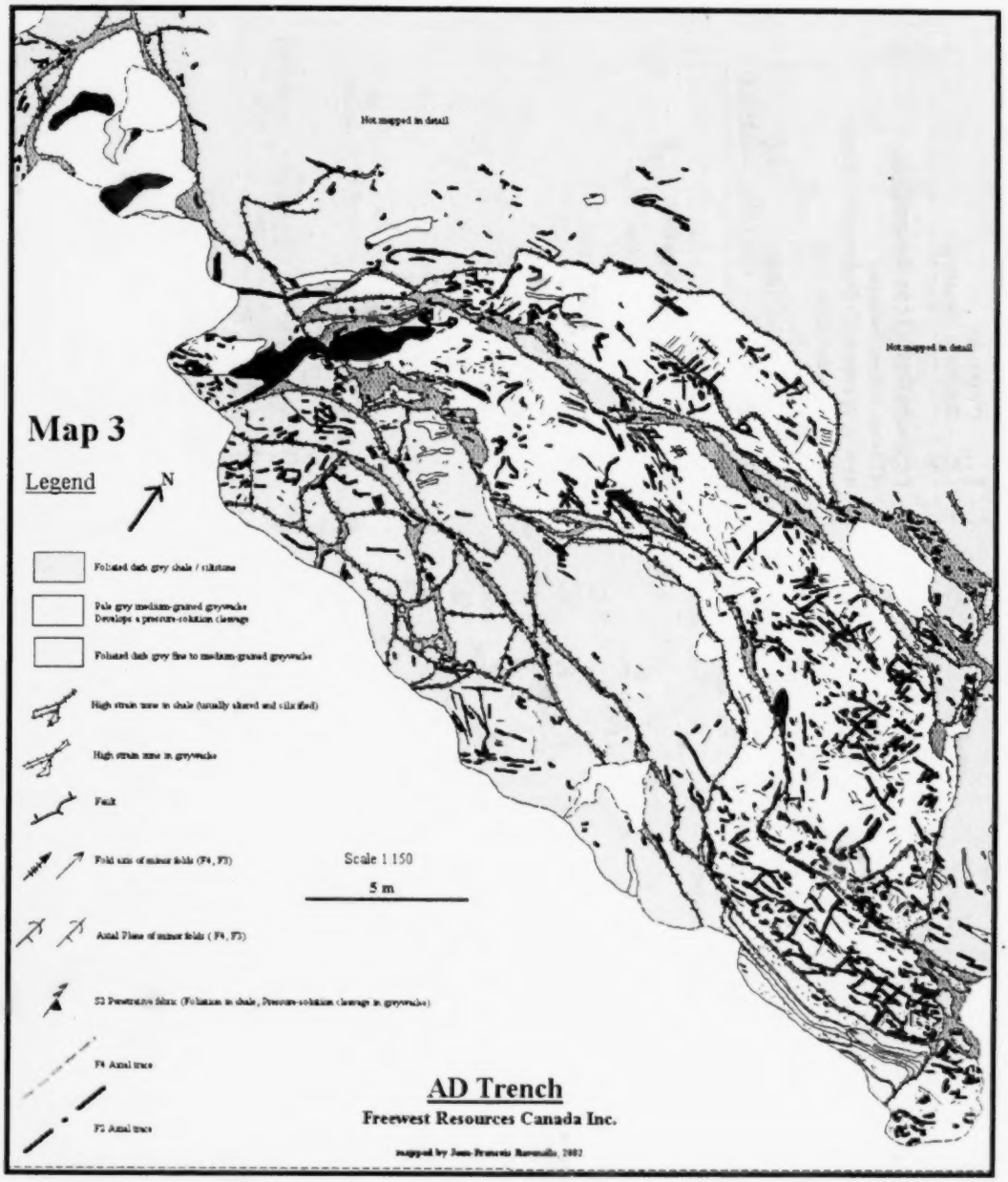
Not mapped in detail
Not mapped in detail
Map 3
Legend
N
Foliated dark grey shale / siltstone
Pale grey medium-grained greywacke
Develops a pressure-solution cleavage
Foliated dark grey fine to medium-grained greywacke
High strain zone in shale (usually sheared and silicified)
High strain zone in greywacke
Fault
Scale 1:150
5 m
Axial Plane of minor folds (F4, F5)
S3 Penetrative fabric (Foliation in shale, Pressure-solution cleavage in greywacke)
F4 Axial trace
F5 Axial trace
AD Trench
Freewest Resources Canada Inc.

Figure 3. Detailed map of the AD Trench (geology by Ravenelle, unpublished information).

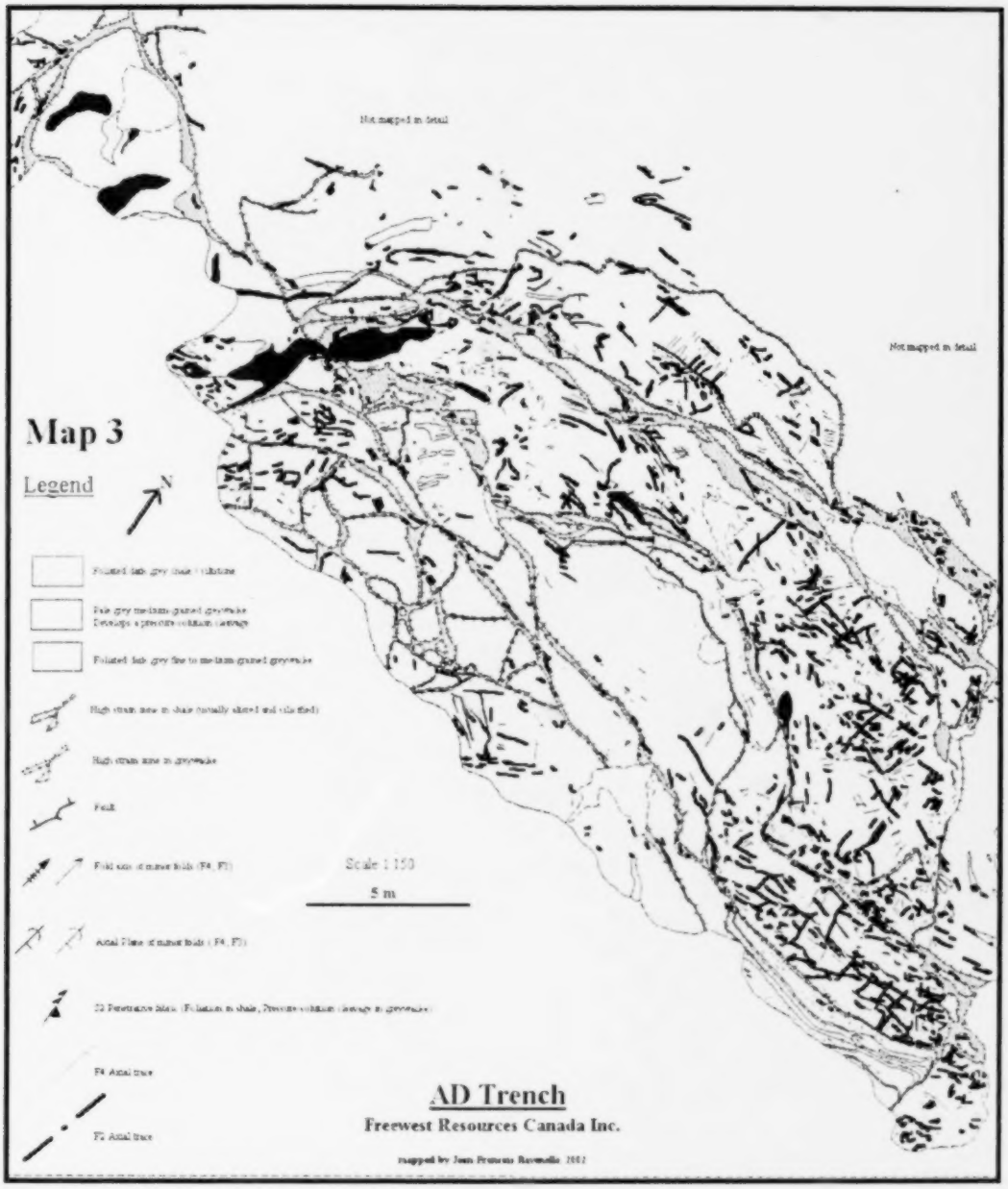

Figure 3. Detailed map of the AD Trench (geology by Ravenelle, unpublished information).

Figure 4. Plan map of AD› Zone, level 2.

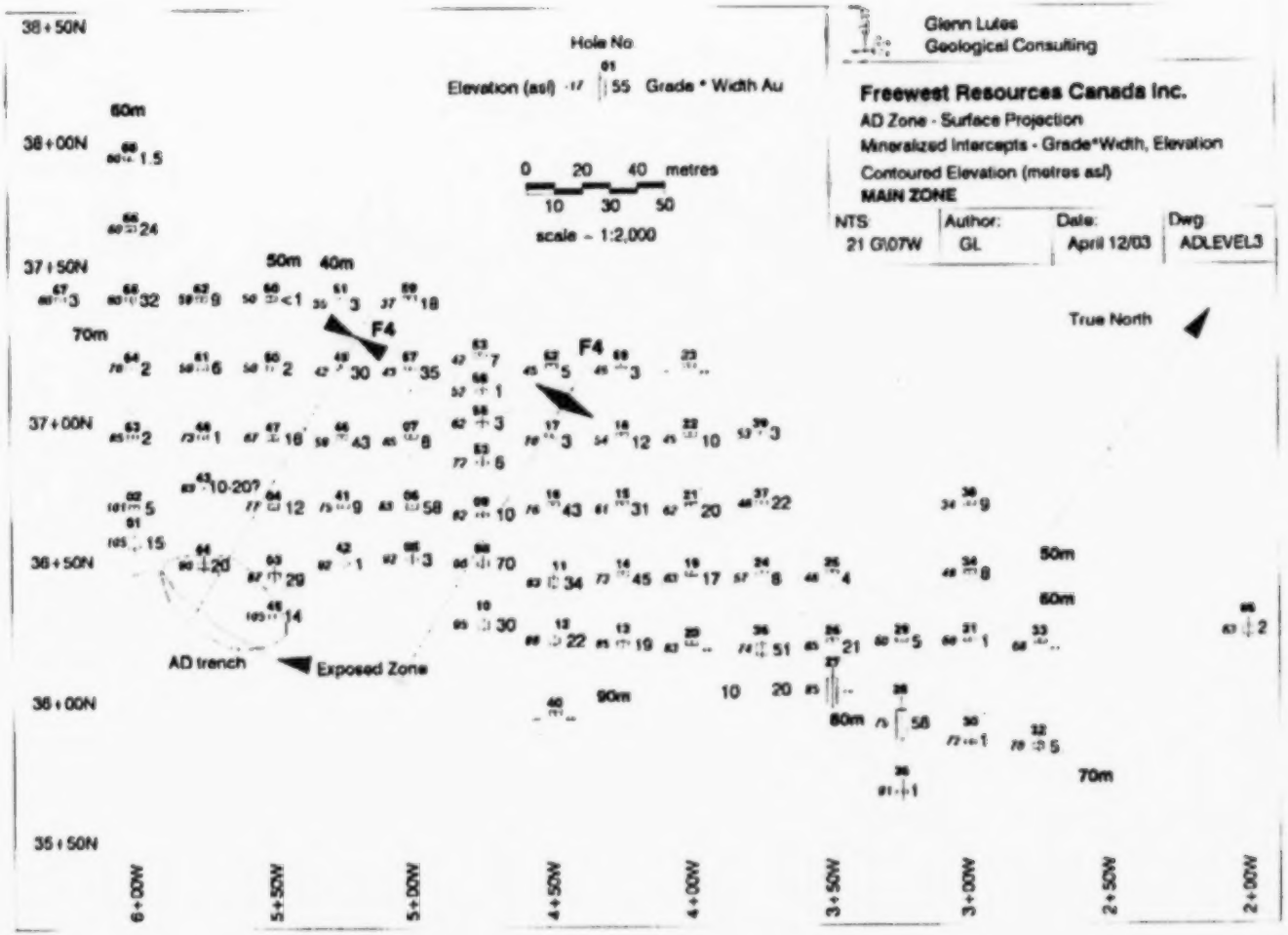

Figure 5. Plan map of the AD Zone, level 3.

Mineralization in the main stockwork zone is characterized by early arsenopyrite-pyrrhotite replacement in the wall rocks followed by quartz veining with associated pyrrhotite, pyrite, stibnite, and with local arsenopyrite, sphalerite and chalcopyrite. Stibnite appears late in the paragenesis and occurs as undeformed semi-massive to massive veins and veinlets. A preliminary mineralogical study of the AD Zone has identified berthierite and gudmundite as common sulphide phase. Trace to rare minerals include jamesonite, ullmannite, tetrahedrite, cobaltite, sphalerite, chalcopyrite, native antimony and nisbite plus native gold and aurostibite.

In the AD trench, a subvertical fracture cleavage is locally developed in the hanging wall of the main zone, post-dates the asymmetric kinks and has a relatively consistent trend at 075-078°. These are developed primarily in the more competent quartz veins and stockwork and are locally infilled by sheeted quartz-stibnite veinlets characteristic of hangingwall-style mineralization at the east end of the trench. This style of mineralization is characterized by coarse stibnite in vuggy undeformed and generally sheeted quartz veins and veinlets at variable attitudes with only local associated alteration and are therefore considered to be late in the paragenesis.

Stop 2 – AD Zone drill core

Drill core from the AD Zone will be available at the former Mount Pleasant mine site for examination.

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Tower Hill Gold Occurrence, southwestern New Brunswick

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**This contribution contains excerpts from Thorne et al. (2002).*

Introduction

Significant gold mineralization in outcrop has been documented in the past in the vicinity of the Tower Hill pluton. This knowledge combined with the age and geochemical similarities between the Tower Hill Granite and Magaguadavic Granite (which has associated gold mineralization; Thorne et al., 2002; Thorne and Lentz, 2003) encouraged Freewest Resources to focus on the Tower Hill area and explore for intrusion-related gold systems.

Exploration History

The original gold showing in the Tower Hill region was discovered by Reg Cox Sr. in the 1960's. It consisted of massive arsenopyrite within quartz-carbonate veins hosted within Ordovician carbonaceous shale and quartzite (Freewest press release, June 20, 2002). This occurrence is situated immediately south of the Honeydale Fault where a regionally penetrative cleavage is deformed by a northeast-trending shear zone, thus generating steeply plunging cross folds (Ruitenberg et al., 1990). Locally, the shear zone is occupied by mafic sills and dykes that are also deformed (Ruitenberg et al., 1990). The most favourably mineralized quartz veins occur near the quartzite-shale contact as well as along the crests of the cross-folds (Ruitenberg et al., 1990). Grab samples returned values up to 89.1 and 19.2 g/t Au and a chip sample ran 50.4 g/t Au 47.3 g/t Ag and 0.29% Co over 0.76 m (Cox, 1963; Ruitenberg et al., 1990). The relationship of this mineralized zone to the intrusion-related gold model still has yet to be determined.

Freewest Resources acquired the Tower Hill property in 2002. It consists of approximately 80 mineral claims and is situated approximately 80 km SSW of Fredericton. Freewest cut a grid and conducted a B-horizon soil sampling survey. Limited channel sampling of trenched exposures has also been undertaken.

Regional Geological Setting

The Tower Hill gold occurrence lies within the polydeformed Calais Formation of the Cookson Group. This formation consists of intercalated black carbonaceous shale and thin bedded siltstone and minor basalt (Fyffe and Riva, 1990). The two phase Tower Hill Granite intrudes the Ordovician rocks of the Kendall Mountain Formation. It is dissected by the NW-trending Oak Bay Fault. An Rb-Sr (muscovite) date gave an isochron age of 401 ± 4 Ma (McLeod et al., 1994; Whalen et al., 1996). This age is very similar to that obtained for the Magaguadavic Granite (396 ± 1 Ma; U-Pb zircon; Bevier, 1990).

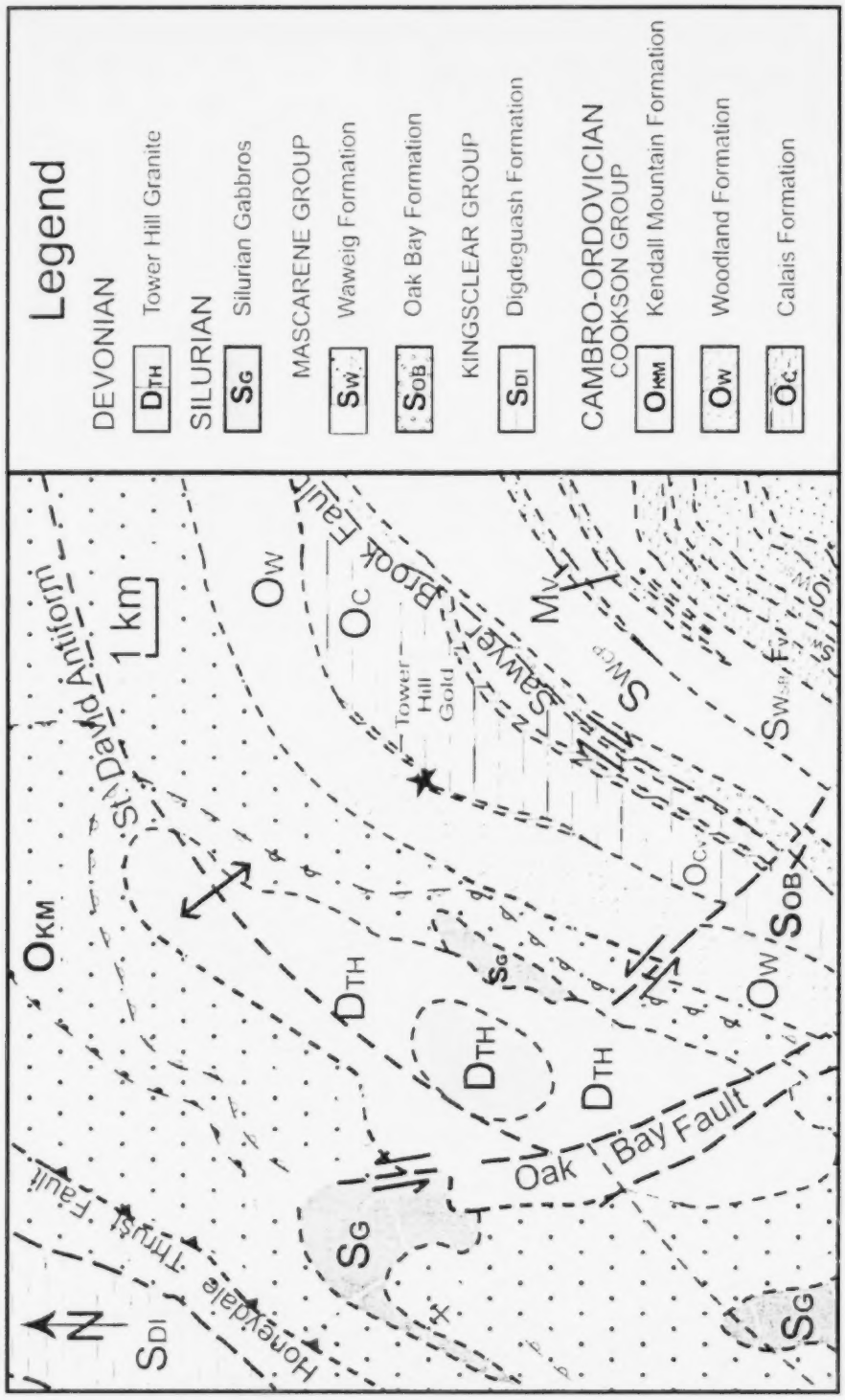


Figure 1. Geology of the Tower Hill area (modified from Fyffe, 1997; McLeod et al., 1998; and Castonguay et al., 2003).

Figure 1. Geology of the Tower Hill area (modified from Fyffe, 1997; McLeod et al., 1998; and Castonguay et al., 2003).

This biotite-muscovite-bearing granite is medium- to coarse-grained and contains variable amounts of mica (Fyffe et al., 1981) as well as accessory zircon and topaz (Whalen et al., 1994). The marginal phase of the granite consists of muscovite granite (leucocratic phase) with abundant associated quartz veins and garnet-tourmaline-bearing pegmatites (Taylor et al., 1985). Weakly mineralized fluorite-bearing quartz veins were recognized along the western margin of the pluton (Taylor et al., 1985). Butt (1976) interpreted the Tower Hill pluton to have crystallized at high pressures thus implying its emplacement at greater depths than the surrounding plutons. Fyffe et al. (1981) agreed with this interpretation based on the extensive high-grade contact aureole that surrounds the pluton.

Acknowledgments

Thanks to Freewest Resources for allowing access to their property and information, and for their assistance with organizing this field trip.

Stops

Stop 1 – Tower Hill Au

The Black Fly trench (Figures 2 and 3) is located within the Tower Hill area in the upper part of the Calais Formation of the Ordovician Cookson Group. The trench consists of two stripped areas separated by 40 metres. Both areas (Black Fly Trench I – 96 m^2 and Black Fly Trench II – 35 m^2) have been mapped in detail and channel sampled for gold analyses.

Stop 1a – Black Fly Trench I: F_3 fold pattern and lithologic control on gold mineralization

Black Fly Trench I exhibits a folded sequence of amygdaloidal basalt, black shale and metasandstone, intruded by a microgranite dyke (Figure 4). The style and orientation of the fold geometry is consistent with folds generated during the third phase of regional deformation, responsible for the creation of the St. David anticlinorium (D_3). A northeast trending, steeply dipping axial-planar foliation (S_3) affects the microgranite dyke, suggesting that the latter intruded the sequence before or during D_3. The affinity of the microgranite and its relationship to the Tower Hill Pluton has yet to be established. Disseminated mineralization is present throughout the sequence, but significant gold concentrations (138 to 421 ppb) were only detected within the amygdaloidal basalt, suggesting lithologic control on gold mineralization.

Stop 2b – Black Fly Trench II: Gold mineralization associated with silicification of microgranite dyke

Black Fly Trench II, located 40 metres east of Black Fly Trench I, exposes an intensively silicified microgranite dyke that intrudes laminated quartzitic siltstone (Figure 5). The highest gold concentration within the trench (3157 ppb over 1 metre) is associated with arsenopyrite-bearing quartz veins within the microgranite dyke. Thin section work is needed to determine whether or not the S_3 fabric affects this vein system, which would indicate whether gold mineralization at this location is pre- or post-D_3. Channel sampling and drilling conducted by Reg Cox Sr. mentioned earlier were carried out at this exposure. The relationship (if any) between the microgranite and the Tower Hill pluton is not known at this time.

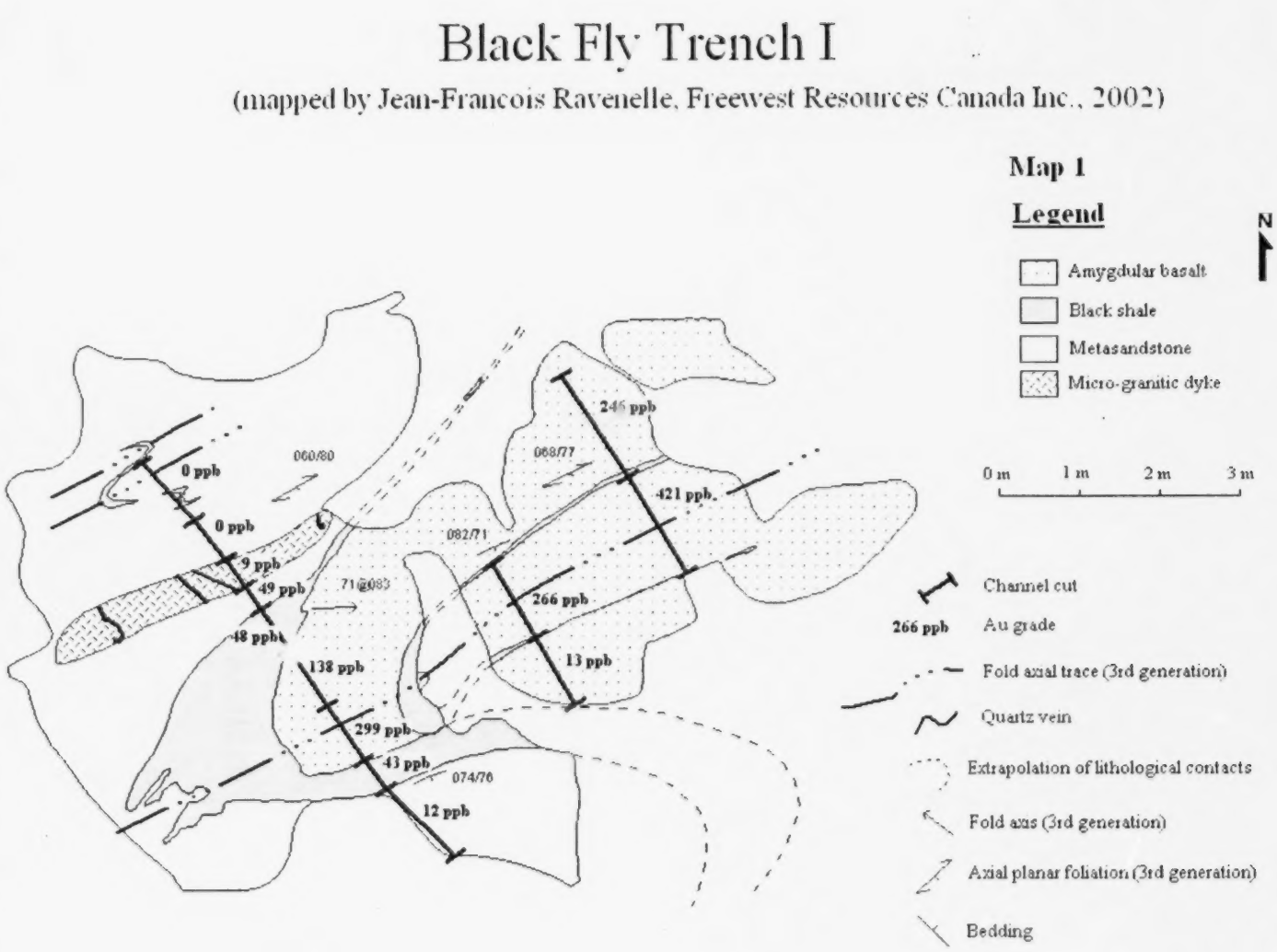
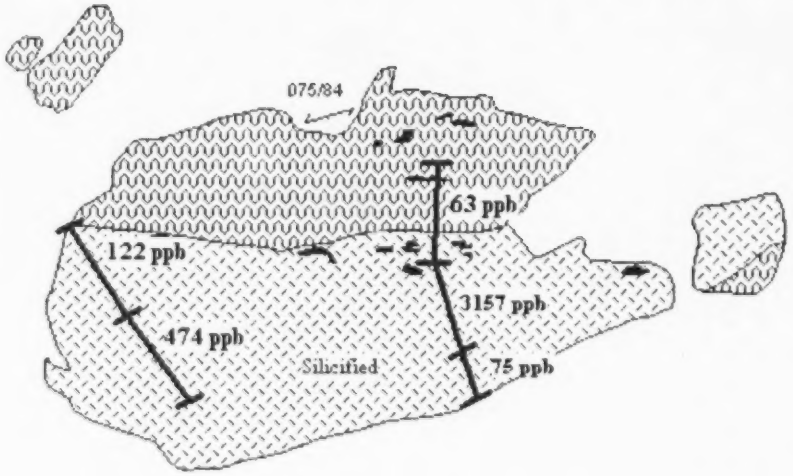


Figure 2. Geology map of Black Fly Trench I at the Tower Hill occurrence (geology by Ravenelle).

Black Fly Trench II

(mapped by Jean-Francois Ravenelle, Freewest Resources Canada Inc., 2002)



Map 2

N

Legend

Laminated quarzitic siltstone

Micro-granitic dyke

0 m 1 m 2 m 3 m

Channel cut

266 ppb Au grade

Quartz vein

Axial planar foliation (3rd generation)

Figure 3. Geology map of Black Fly Trench II (geology by Ravenelle).

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The Springfield Gold Prospect, west-central New Brunswick

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Introduction

The Springfield gold occurrence is located approximately 25 km northwest of Fredericton, immediately north of Springfield, New Brunswick (Fig. 1). This property straddles Highway 651 (UTM 6 483 71E; 50 974 67 N on NTS Mapsheet 21J/3E) and is currently being explored in an attempt to constrain the mineralized zone.

Exploration History

Since its discovery in the late 1980's, several mining companies have carried out detailed exploration programs in the Springfield area. Companies such as Corona Mining Corporation and Rio Algom mapped and sampled the main breccia outcrops. Later exploration by Noranda included detailed prospecting, geophysical surveying (VLF and magnetics), soil geochemistry, and two diamond drill holes (Woods and Rankin, 1991). Current prospecting by Crystal Gold, TNR, and Merton Stewart resulted in collaring four more diamond drill holes. A total of over 700 m of drilling has been conducted in an attempt to constrain the geometry of the breccia system and assess the distribution of gold in the system.

Local Geological Setting

This mineral occurrence is a gold-bearing, subvertical, sulphide-carbonate-quartz mineralized discordant breccia zone (< 10 m true width) hosted in the Silurian Kingsclear Group. This east-west trending mineralized zone lies on the northeastern flank of the high-level, Early Devonian Hawkshaw biotite granite phase of the Pokiok Batholith. The breccia zone is hosted within a northeast-striking sequence of grey quartzose greywacke, grey lithic greywacke, grey slate, grey pyritiferous slate, and minor grey calcareous slate (Caron, 1996). The fault zone postdates the S_2 fabric development in the sedimentary sequence. Ductile strain associated with and preceding brittle deformation is manifested by narrow (0.5m) foliated zones, representing altered and sheared sedimentary units. These foliated zones mantle the mineralized breccia system.

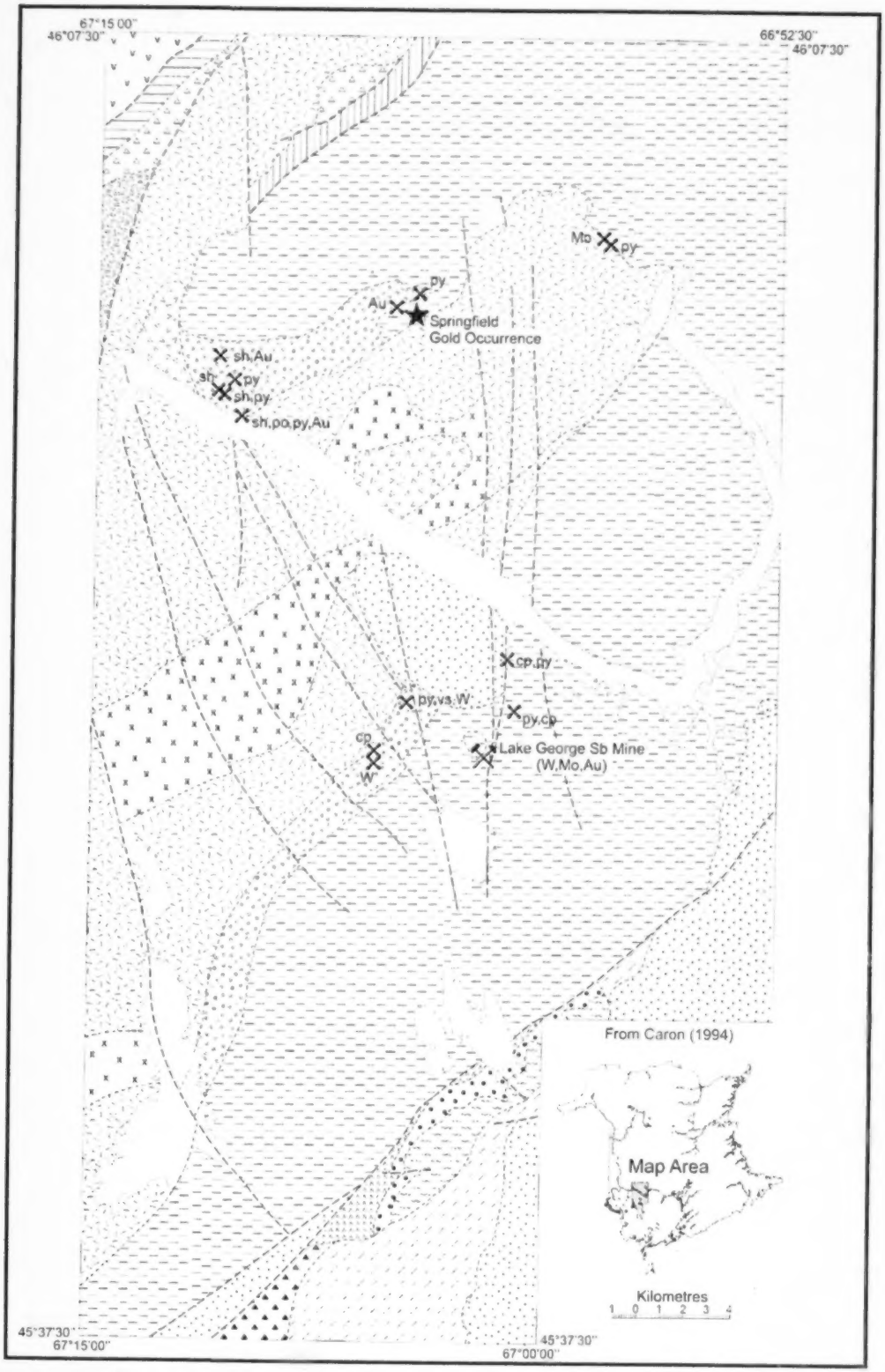


Figure 1a. Location of the Springfield property, northern Pokiok Batholith (from Caron, 1994).

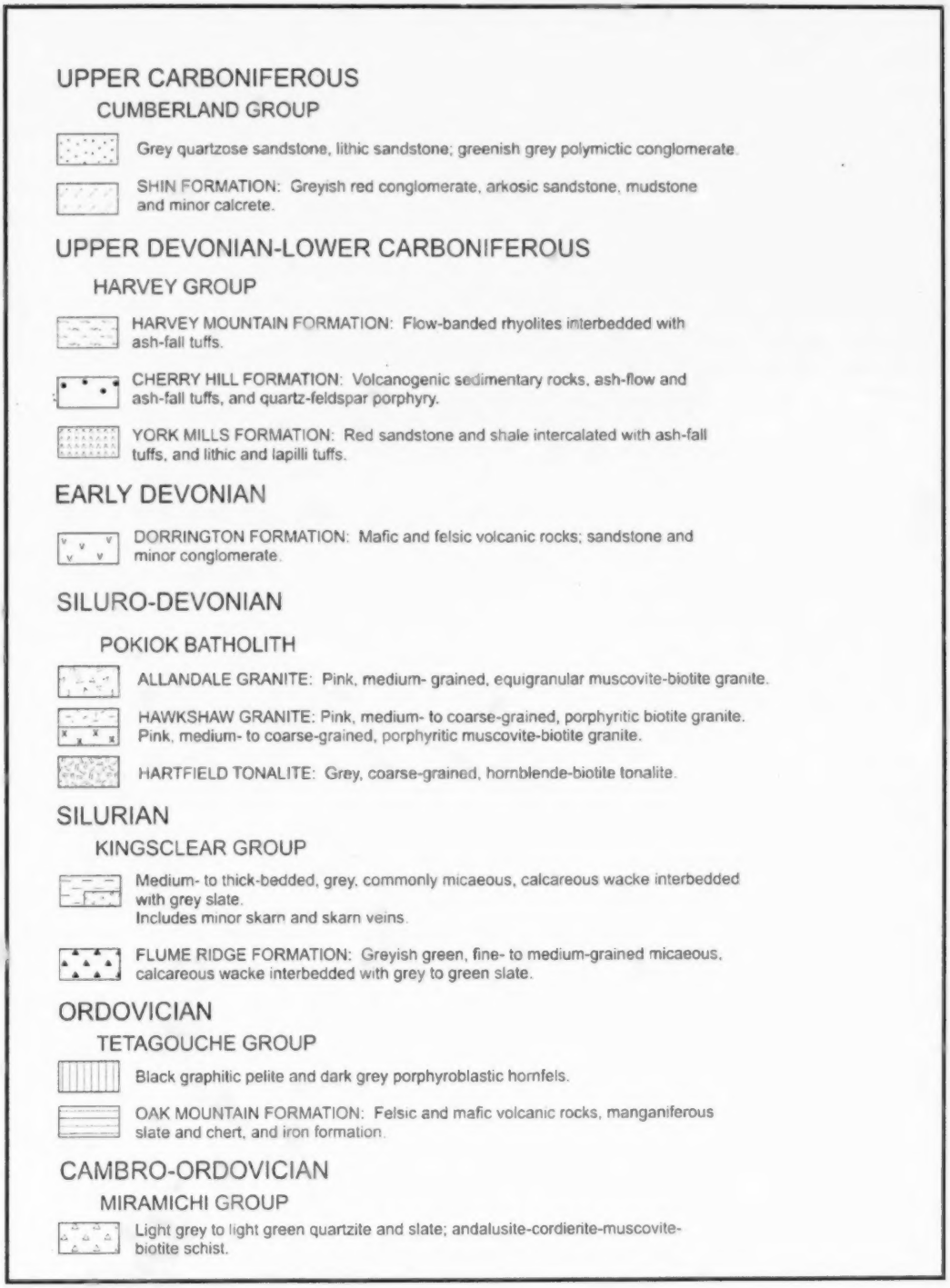

UPPER CARBONIFEROUS
CUMBERLAND GROUP
Grey quartzose sandstone, lithic sandstone; greenish grey polymictic conglomerate.
SHIN FORMATION: Greyish red conglomerate, arkosic sandstone, mudstone and minor calcrete.
UPPER DEVONIAN-LOWER CARBONIFEROUS
HARVEY GROUP
HARVEY MOUNTAIN FORMATION: Flow-banded rhyolites interbedded with ash-fall tuffs.
CHERRY HILL FORMATION: Volcanogenic sedimentary rocks, ash-flow and ash-fall tuffs, and quartz-feldspar porphyry.
YORK MILLS FORMATION: Red sandstone and shale intercalated with ash-fall tuffs, and lithic and lapilli tuffs.
EARLY DEVONIAN
DORRINGTON FORMATION: Mafic and felsic volcanic rocks; sandstone and minor conglomerate.
SILURO-DEVONIAN
POKIOK BATHOLITH
ALLANDALE GRANITE: Pink, medium- grained, equigranular muscovite-biotite granite.
HAWKSHAW GRANITE: Pink, medium- to coarse-grained, porphyritic biotite granite.
Pink, medium- to coarse-grained, porphyritic muscovite-biotite granite.
HARTFIELD TONALITE: Grey, coarse-grained, hornblende-biotite tonalite.
SILURIAN
KINGSCLEAR GROUP
Medium- to thick-bedded, grey, commonly micaeous, calcareous wacke interbedded with grey slate.
Includes minor skarn and skarn veins.
FLUME RIDGE FORMATION: Greyish green, fine- to medium-grained micaeous, calcareous wacke interbedded with grey to green slate.
ORDOVICIAN
TETAGOUCHE GROUP
Black graphitic pelite and dark grey porphyroblastic hornfels.
OAK MOUNTAIN FORMATION: Felsic and mafic volcanic rocks, manganiferous slate and chert, and iron formation.
CAMBRO-ORDOVICIAN
MIRAMICHI GROUP
Light grey to light green quartzite and slate; andalusite-cordierite-muscovite-biotite schist.

Figure 1b. Legend to accompany map shown in Fig. 1a.

Breccias

The gold-mineralized breccia is characterized by medium sized (5-8 cm), green and black angular to subrounded breccia clasts. The green breccia clasts have a granophyric texture similar to the fine-grained crosscutting granites located at deeper levels as is evident in drill core. Based on petrographic and geochemical analysis (specifically immobile trace-elements), these green clasts are similar in composition (evolved I-type) to the granophyric dikes (Table 1). These clasts are relatively devoid of any mineralization except for large zoned arsenopyrite grains that are contained in the larger crosscutting quartz veins. The orientation, geometry (jigsaw fit), and angularity of individual granophyric clasts indicate a low degree of clast mobility and reflect intense hydrofracturing. Black breccia clasts appear slightly more rounded, indicating relatively higher mobility than their granophyre-derived counterparts. Petrographically they contain very fine-grained sericite and quartz in association with very fine-grained clusters of arsenopyrite and disseminated pyrite. Sericite, quartz, and opaques have developed within individual breccia fragments, which have a microfabric, indicative of a previous strain episode or reflecting S_2.

Both black and green fragments are supported by a fine-grained black matrix, which is dominated by microscopic clusters of arsenopyrite and disseminated euhedral pyrite. This system has experienced a second brecciation event represented by extensive quartz and carbonate veining. There are four distinct veining events; a pre-brecciation clean quartz veining event oriented ~80 degrees towards 230°, and three syn- to post-brecciation phases composed of dirty carbonate and clean quartz, which anastomose (80° towards 300° and 73° towards 190°). The arsenopyrite formed during early stages of quartz-carbonate flooding, as evidenced by their tendency to mantle quartz-carbonate veins.

On the basis of crosscutting features observed in all four drill holes, a relative chronology of fluidization, mineralization, and alteration can be established. Firstly, hydrofracturing of the host sedimentary rocks is evident. This event is most likely genetically related to a cupola at depth associated with the adjacent high-level Hawkshaw granite, similar to the Lake George W-Mo-Au-Sb deposit. Gold-bearing As-S-rich fluids were introduced, which began to alter the protolith and deposit arsenopyrite and pyrite. Hydrofracturing and fluidized breccia formation continued, which is characterized by multi-phase, large-scale open vein infilling of comb texture quartz. This main brecciation event may be fault related and seems to be responsible for the main alteration episode. Alteration mantling the sediment-hosted breccia zone is dominantly sericite and ankerite with a lesser proportion of grey argillic alteration peripheral to the sericitized zones. The sericite alteration is characteristically composed of fine-grained sericite and minor pyrite and gold-bearing arsenopyrite, which appears interstitial to quartz grains. In the final stages of breccia development, fluorine-bearing fluids deposited fluorite in crosscutting veins (2-8 cm). Fluorite is probably related to greisenization of the Hawkshaw granite at depth, as observed in drill hole 2002-4.

Fault Zone Geometry

The geometry of the breccia system has been constrained by four diamond drill holes totaling 602.02 m (NQ size drill core). The 2002 drilling program on the Springfield project consisted of two diamond drill holes. One was drilled to intersect the target breccia at depth below hole 2001-03. Another was planned to test a localized arsenic soil anomaly coincident with a VLF-EM response defined by Noranda on line 99E, 95+50N (Fig. 2). This hole was attempted,

Table 1. Geochemical Data for the Springfield felsic intrusions and various phases of the Pokiok Batholith

Sample	03-MA-24	03-MA-25	03-MA-22	Allandale	Hawkshaw	Skiff Lake	Hartfield	Lake George
SiO_2	60.93	66.48	65.08	71.58	69.07	68.9	62.13	66.56
TiO_2	0.86	0.19	0.72	0.27	0.48	0.52	0.95	0.55
Al_2O_3	19.19	20.78	15.81	14.45	14.75	14.93	16.08	14.55
Fe_2O_3	7.72	1.69	4.5	0.5	0.96	0.76	1.35	3.26
FeO	***	***	***	1.09	1.63	2.39	3.6	***
MnO	0.1	0.04	0.07	0.06	0.07	0.08	0.09	0.06
MgO	2.66	0.91	3.63	0.52	0.98	1.12	2.39	1.17
CaO	2.46	1.8	5.44	1.34	2.18	2.07	4.41	2.79
Na_2O	0.05	0.18	0.05	3.78	3.73	3.43	3.67	3.39
K_2O	3.62	5.87	3.95	4.36	4.26	3.82	2.78	3.32
P_2O_5	0.13	0.07	0.12	0.18	0.18	0.18	0.23	0.13
LOI	***	***	***	0.96	0.77	0.85	0.95	2.49
Total	97.72	98.01	99.37	99.3	99.3	99.2	98.8	98.2
As	92.5	71.1	1180	0.9	1.6	1.8	1.2	46.4
Ba	120	350	260	310	414	511	470	465
Br	0.5	0.5	0.5	***	***	***	***	***
Ca	1	1	3	***	***	***	***	***
Co	12	3	14	7	6	8	14	8
Cr	122	11	131	10	12	20	32	15
Cs	35	27	27	14.4	10	8.3	6.1	7.6
Hf	6	4	7	4	5	6	6	5
Hg	1	1	1	***	***	***	***	***
Ir	-5	-5	-5	***	***	***	***	***
Mo	2	18	-1	2	1	1	1	9
Ni	71	-23	107	3	5	10	11	8
Rb	185	304	290	235	193	162	113	137
Sb	3.1	1.9	3.3	0.3	0.4	0.4	0.3	6.5
Sc	12.6	3.9	11.7	5.3	8.2	9.7	14.7	8
Se	-3	-3	-3	1	2	2	2	1
Ta	0.8	1.9	1	2.1	1.8	1.45	1.53	1.77
Th	8.2	9.8	7.9	13.3	16.7	13.7	11.9	14
U	1.8	9.1	2	5.8	4.1	3.3	4	7.1
W	10	10	23	3	1	1	1	9
Zn	91	-50	81	38	46	52	69	47
La	37	23.5	34.4	***	***	***	***	***
Ce	77	50	70	46	78	71	82	51
Nd	19	10	19	20	31.61	30.6	32.9	13.7
Sm	6.7	4.7	6.5	3.9	5.8	5.8	6	4.2
Eu	1.5	1	1.3	0.7	1.2	1.3	1.5	1.1
Tb	0.5	0.5	1	0.6	0.9	0.9	0.9	0.8
Yb	2.9	2.8	2.9	1.6	2.7	2.6	2.6	2.2
Lu	0.45	0.42	0.45	0.2	0.4	0.4	0.4	0.3

Notes: 03-MA-25 is a sample of the granite intersected in drill holes 2001-3 & 2002-4; 03-MA-24 is a sample of the granophyric breccia clasts; 03-MA-22 is a sample of the crosscutting granophyric dike that is intersected by drill hole 2002-4. Samples 03-MA-24, 03-MA-22, and 03-MA-25 were analyzed at Memorial University of Newfoundland by XRF on pressed pellets. Trace element analysis was performed by INAA at Activation Labs. Geochemical data for phases of the Pokiok Batholith from Whalen (1993) and Yang et al. (2002).

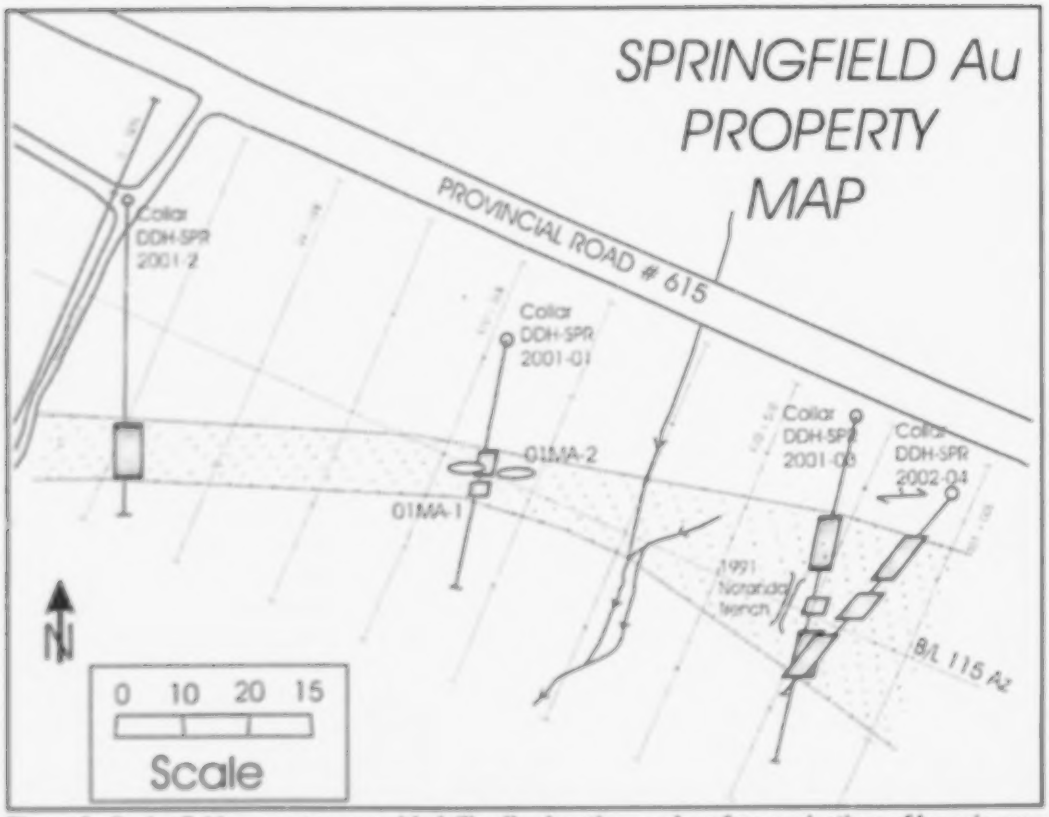


Figure 2. Springfield property map with drill collar locations and surface projections of breccia zone from depth for all four drill holes (modified after Penner, 2001). MA-02-04a represents the rim of a pyrite grain noted in a quartz vein. MA-02-04b is the core of MA-02-04a. MA-02-04c is an arsenopyrite grain noted in the breccia matrix.

but could not be completed due to excessive overburden and equipment problems; the only site available was atop an esker (Penner, 2001). Hole 2001-03 was collared at 1+65E, 0+50N, azimuth 091° at -60° with breccia being intersected at depth north of the baseline and directly below the baseline. Hole 2002-04 was collared across the road to the northeast at 101+20E, 1+15N, azimuth 230° at -60° in order to intersect the downward projection of the breccia intersected in 2001-03 at further depth. A zone of fracturing leading into breccia development was intersected from 168.3m to 206.3m, with fracturing to 210.3m, approximately 90m below the upper interval in hole 2001-03 and 140m below surface. The zone (and the sediments) terminates abruptly against a contact with altered granite, which is thought to represent the Hawkshaw phase of the Pokiok Batholith. Holes DDH SPR 2001-3 and DDH SPR 2002-4 terminate in coarse-grained granite at 278.1m depth.

These four drill holes were plotted on the preexisting Noranda baseline map, and projected from depth to indicate the trace of the main breccia system at surface (Fig 2). This yielded a curved anastamosing breccia system approximately 10m wide to the west and widening to the east to approximately 20 m, striking 110 degrees. These drill logs were then plotted in three dimensions in a block diagram, viewed at 30 degrees towards 320° (Fig. 3).

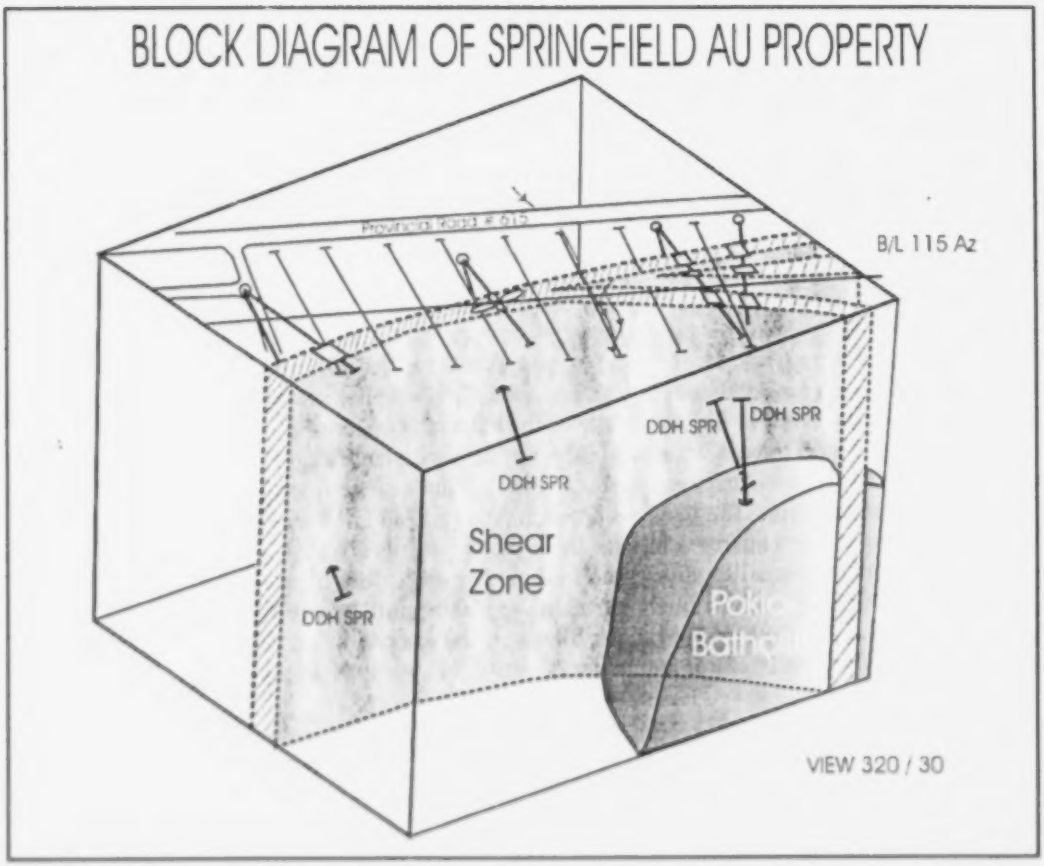
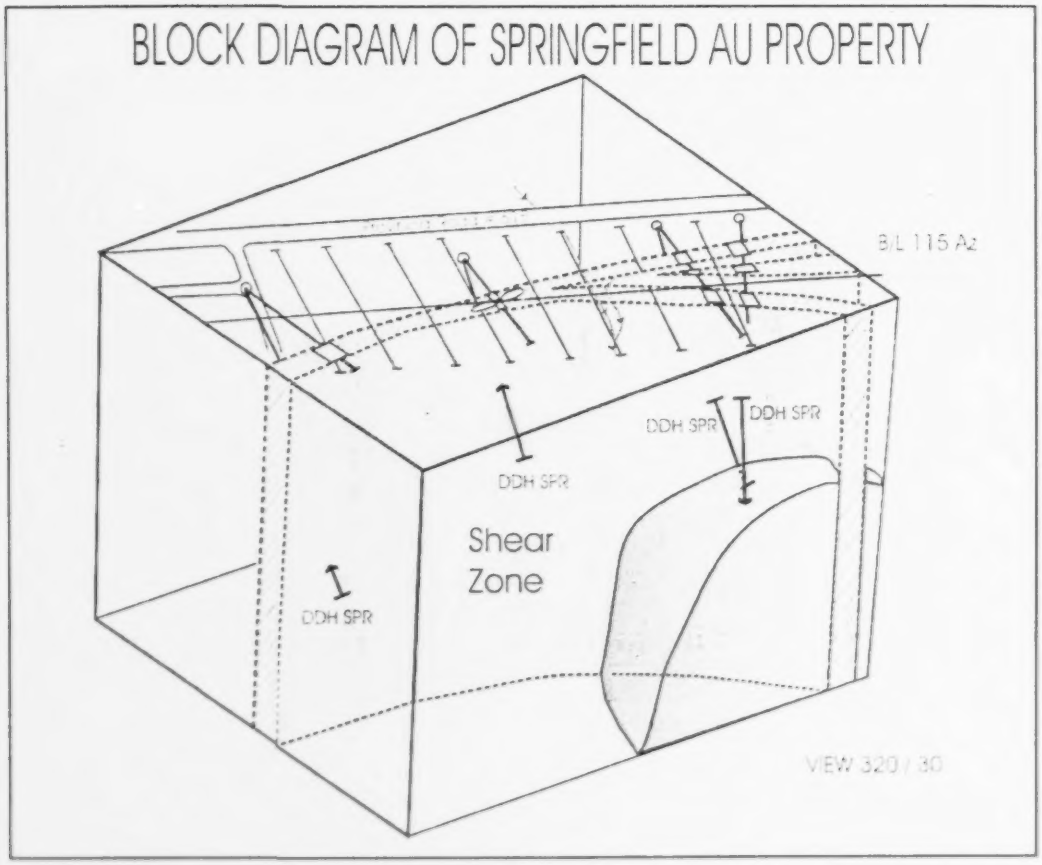


Figure 3. Block diagram of Springfield gold property projected 30° towards 320° from drill core analysis.

Mineralization

Several breccia zones and hydrothermally altered host rocks, which were intersected in three drill holes (TNR Resources, 2001), were sampled in detail for geochemical analysis. Analyses were conducted at Chimitec-Bondar Clegg Laboratories in Val d'Or, Quebec. Gold was determined by Fire Assay - Atomic Absorption Spectroscopy (FA-AAS) and remaining trace elements were analyzed by Inductively Coupled Plasma-Emission Spectometry (ICP-ES) methods (see Penner, 2001). The first breccia zone in drill hole 2001-1 (60.3 to 66.87 m) averaged 150 ppb over 6.57 m with >9000 ppm As (n=5). Another breccia zone between 90.06 and 103.96 m yielded <25 ppb Au (n=6). Lower gold results in the upper breccia zone (81 to 90 m and 115 to 121 m) intersected by drill hole 2001-2 yielded <90 ppb Au (n=9) over 9.0 m and <15 ppb Au over 6.0 m (n=4), respectively. In drill hole 2001-3, several interesting breccia zones were intersected. The interval between 32.75 and 39.15 m had anomalous As (average 3350 ppm) and Au (average 62 ppb) values (n=5) over a width of 6.4 m. From 42.25 to 70.15 m, gold values averaged 87 ppb Au (n=13) accompanied by anomalous As (1490 ppm) over a zone 37.9 m wide. A higher grade breccia zone from 84.6 to 111 m yielded average values of 135 ppb Au and 4200 ppm As (n=14). The lower most zone (from 117.78-123.3 m) had average values from four samples of 61 ppb Au and 3580 ppm As.



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The breccia zone intersected in the most recent round of drilling conducted by TNR Resources in 2002 was sampled. A total of 23 samples averaging 1.5 m (0.9 to 2 m) in length were collected from the interval and analysed by FA-AAS and ICP-ES at ALS Chemex. As anticipated by the presence of arsenopyrite, anomalous arsenic values are recorded, ranging from 162 to 6880 ppm. The lowest value occurs within a group of six samples at the end of the zone, whose range is from 162 to 888 ppm, where arsenopyrite content was seen to diminish. The majority of the rest of the zone has arsenic values ranging from 434 to 6880 ppm, within which twelve samples exceed 1000 ppm As. Associated gold values within this zone are very low, ranging from < 5 ppb (detection limit) to 85 ppb.

In addition to the above zone, three others were sampled from the last hole drilled in 2002. The first is a 0.9 m breccia interval within argillite from 51.6 to 52.5 m with a mostly carbonate matrix and trace arsenopyrite. It returned 54 ppm arsenic and less than 5 ppb gold. The second is a fault zone within the metasediments at 88.6 to 94.25m, which consists of unconsolidated core fragments and coarse sand to 89.4m, mostly sand to 91.1m and more competent but broken core to 94.25m. The latter interval consists of grey metasediment fragments, as well as quartz fragments in a rusty quartz-carbonate matrix. Arsenic values range from 20 to 208 ppm, but gold is below the detection limit. The third occurs within the altered granite at 261.7m, where a 20 cm interval straddling a 6 cm quartz vein with large patches of pyrite-arsenopyrite occur in both the vein and wallrock. This small interval produced the highest values of 9480 ppm arsenic and 195 ppb gold, combined with anomalously elevated Ag (30.6 ppm), Mo (681ppm), Zn (1330 ppm), Pb (671 ppm), and Cu (696 ppm) values; however, the granite in general features only a few carbonate- $\pm$ quartz-filled fractures and minor disseminated pyrite (+ arsenopyrite?).

Overall, the anomalous gold assays are directly correlative with As and S abundance, with a low abundance of antimony (<< 50 ppm), molybdenum (<< 60 ppm), silver (<< 1.7 ppm), and other base-metals, with W, Bi and Te not detected (< 10 ppm, < 5 ppm, and < 10 ppm, respectively).

Conclusion

It would appear from the combined results of this and previous exploration efforts that the breccia zone itself can be traced both along strike and to depth, either as multiple zones or as a single anastamosing planar body. It continues to be characterized by anomalous arsenopyrite mineralization with which elevated gold values are associated. These gold values, however, are far from being of economic significance, but may yield higher assays to the east as the zone widens.

Acknowledgments

The authors thank Mr. Merton Stewart for introducing us to this property. We would also like to thank Dr. Steve McCutcheon and Jim Walker for their assistance and time in analyzing drill core. Xueming Yang was a great help in understanding the various phases of the Pokiok Batholith and surrounding geology. Also thanks to Dr. Douglas Hall (UNB), who assisted in performing SEM-EDS analyses. Ken Mersereau and Terry Leonard (NBDNRE) assisted with the figures.

Stops

The mineralized hydrothermal breccia exposed in outcrop and drill core will be examined at this location.

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Lake George Antimony Mine, West-Central New Brunswick

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Introduction

The Lake George antimony vein deposit, the former largest Sb producer in North America, is located in York County, approximately 35 km southwest of Fredericton, New Brunswick (Fig. 1a). This deposit is spatially and temporally associated with earlier W-Mo mineralization that is related to an Early Devonian granodiorite stock exposed only at depth (Seal et al., 1987, 1988; Procyshyn and Morrissy, 1990; Caron, 1996; Chi, 2002; Lentz et al., 2002a; Yang et al.; 2002a, b). Gold anomalies are widespread in drill core around the property (Morrissy, 1991a) and ore-grade gold zones (up to 0.54 oz/t Au) are locally developed (Morrissy, 1991b; Lentz et al., 2002a). The occurrence of Au-bearing quartz-carbonate veinlets and stockworks associated with W-Mo mineralization within the granodiorite stock and near the contact in the metamorphic aureole, strongly suggests that Au mineralization is related to the intrusion (Seal II et al., 1988; Lentz et al., 2002a, b). Elsewhere in the world, gold mineralization in granitic domains has been documented to be mainly related to metaluminous, subalkaline intrusions of intermediate to felsic composition, which span the boundary between reduced ilmenite and oxidized magnetite series, in continental tectonic settings well inboard of convergent plate boundaries (Thompson et al., 1999; Lang et al., 2000; McLeod and McCutcheon, 2000; Chi et al., 2001; Lang and Baker, 2001; Thorne et al., 2001, 2002). A preliminary study of the petrochemical attributes of the Lake George granodiorite (Yang et al., 2002a) suggests that it is broadly similar to those gold-associated granitoids (Thompson et al., 1999; Lang et al., 2000; Lang and Baker, 2001; Thorne et al., 2001, 2002). This Early Devonian granodiorite (U-Pb zircon age of 412 ± 2 Ma, M.J. McLeod, personal communication, 2002) may have formed by partial melting of lower crustal amphibolitic rocks in a volcanic arc to late orogenic environment, and is genetically linked to fractionation of the Hawkshaw phase (U-Pb titanite age of 411 ± 1 Ma; Whalen, 1993) of the Pokiok Batholith (Fig. 1a; see Yang et al., 2002a).

Petrological and fluid inclusion studies of the Lake George granodiorite show that the major rock-forming minerals (i.e. plagioclase, K-feldspar, biotite) appear disturbed and partially reset by subsolidus and/or late stage hydrothermal processes (Yang et al., 2002b, in review). These fluids are similar to those found in the two styles of mineralization (Scratch et al., 1984; Seal et al., 1987, 1988).

Regional and Local Geologic Setting

The Lower Silurian, locally calcareous or marly turbiditic sediments (Seal II et al., 1987, 1988; Caron, 1996) of the Kingsclear Group (Fyffe and Fricker, 1987) comprise the host rocks to the Lake George deposits (Fig. 1b). These rocks are regionally metamorphosed to greenschist grade and tightly folded into upright to steeply northwest-dipping, northeast-trending, doubly

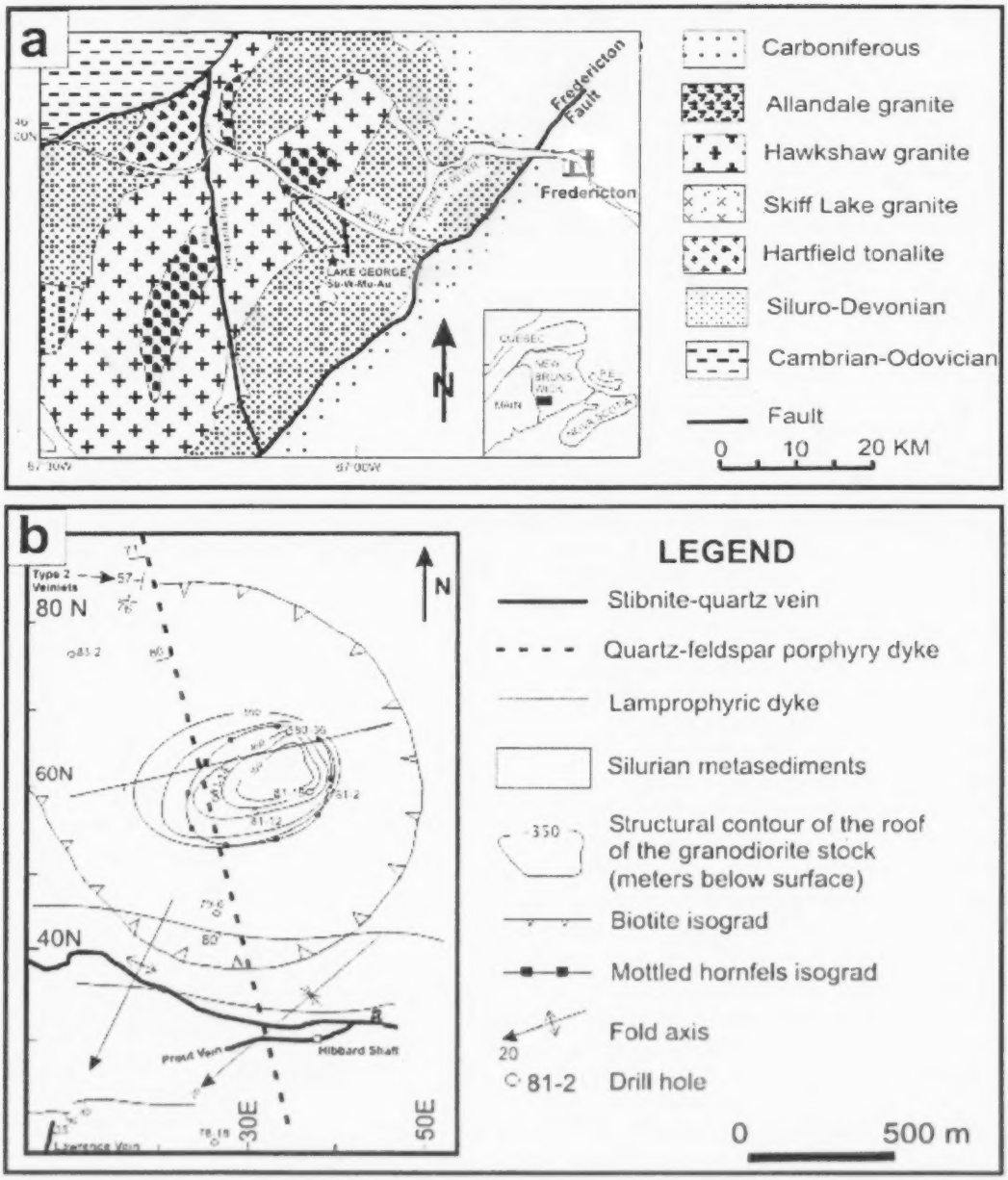

Figure 1. (a) Location and general geology of the Lake George and Pokiok area, New Brunswick (modified after Procyshyn & Morrissy 1990, McLeod 1994); (b) Schematic geological map of the Lake George mine site (modified after Seal II et al. 1987, Procyshyn & Morrissy 1990). The location of the Lake George granodiorite stock is depicted as structural contours of its upper contact (in metres below the surface). Note the concentric disposition of the biotite and mottled hornfels isograds about the stock.

plunging anticlines and synclines with axial planar cleavage (Caron, 1996). The overall trend of units in the Kingsclear Group parallels the southern margin of the syn- to late-tectonic Early Devonian granitic to granodioritic Pokiok Batholith (Fig. 1a). Narrow shoshonitic lamprophyre dykes of calc-alkaline affinity intrude in an overall east-west orientation and generally dip steeply southward (Lentz et al., 2002b). These are in turn intruded by a 3-5 m wide, north-northwest-trending quartz-feldspar porphyry dyke (Fig. 1b, see Procyshyn and Morrissy, 1990). Intruding the entire package of metasediments and dykes is the Lake George granodiorite stock that shows reduced I-type characteristics (Yang et al., 2002a and b) similar to other subalkaline intrusions associated with gold deposits elsewhere. The cusp of the granodioritic stock at Lake George lies about 350 metres at depth below the present erosion level. Cordierite and biotite isograds delineated by Scratch et al. (1984) outline symmetrical contact metamorphism and overprinting metasomatism (W-Mo-Au) associated with this high-level stock. The contact metasomatic mineralized system and associated granodiorite is then cut by the Au-bearing polymetallic and the main antimony vein systems (Morrissy and Ruitenberg, 1980; Seal et al., 1988; Procyshyn and Morrissy, 1990; Lentz et al, 2002a).

The fine- to medium-grained porphyritic granodiorite consists of quartz, plagioclase, orthoclase, biotite, hornblende, and accessory minerals such as titanite, zircon, apatite, ilmenite, trace magnetite, and sulphides (pyrrhotite, pyrite, and arsenopyrite). Phenocrysts, 2-4 mm in size, include subhedral plagioclase with normal zonation, euhedral to subhedral hornblende, and subhedral to anhedral biotite. Partially resorbed quartz was also found in some of the phenocrysts. A few microperthite grains occur as phenocrysts, indicating subsolidus exsolution at temperatures lower than 500°C (Tuttle and Bowen, 1958). Grains in the groundmass are usually less than 1 mm in size, and are composed of quartz, K-feldspar, plagioclase, biotite, and amphibole. Acicular apatite is often included in plagioclase, biotite, and amphibole phenocrysts. Titanite may occur as a primary phase, but most appears to be secondary products of amphibole and biotite alteration, where it is associated with chlorite, magnetite, and calcite. Sericite alteration is ubiquitous in plagioclase cores or along cleavage traces and the outer margin. Chloritic alteration of biotite and amphibole is common. Under electron probe microanalyser (EPMA) in scanning mode, a number of muscovite lamellae were observed along cleavages within igneous biotite, reflecting weak partial alteration of selected phases. Textural relations show that apatite and ilmenite were the early phases to crystallize from the melt. At the same time and following, hornblende crystallized; after which simultaneous crystallization of biotite and plagioclase, and later, quartz and orthoclase occurred. Most of the sulphides seem to be of hydrothermal origin, but some of the pyrrhotite and pyrite enclosed in hornblende and biotite may be primary (magmatic). The granodiorite intrusion has a low magnetic susceptibility (4 to 21 x 10^{-5} SI, ave. 6 x 10^{-5} SI), based on measurements of the drill core with the Exploranium KT-9. This indicates low magnetite content (Ishihara, 1981), consistent with ilmenite as the dominant Ti-Fe oxides in the intrusion. This is consistent with the reduced I-type character of the Lake George granodiorite (Yang et al., 2002a), whereas the Hawkshaw granite is a more oxidized I-type granitoid (Shabani, 1999; Whalen, 1993).

Mineralization Styles and Mineral Assemblages

The various mineral deposits at Lake George (Fig. 1b & 2) include gold-bearing W-Mo mineralization (Type I), polymetallic veins (Type II), and Hibbard, Lawrence, and Prout gold-bearing antimony veins (Type III). This suggests that the gold-forming process is a protracted event at Lake George.

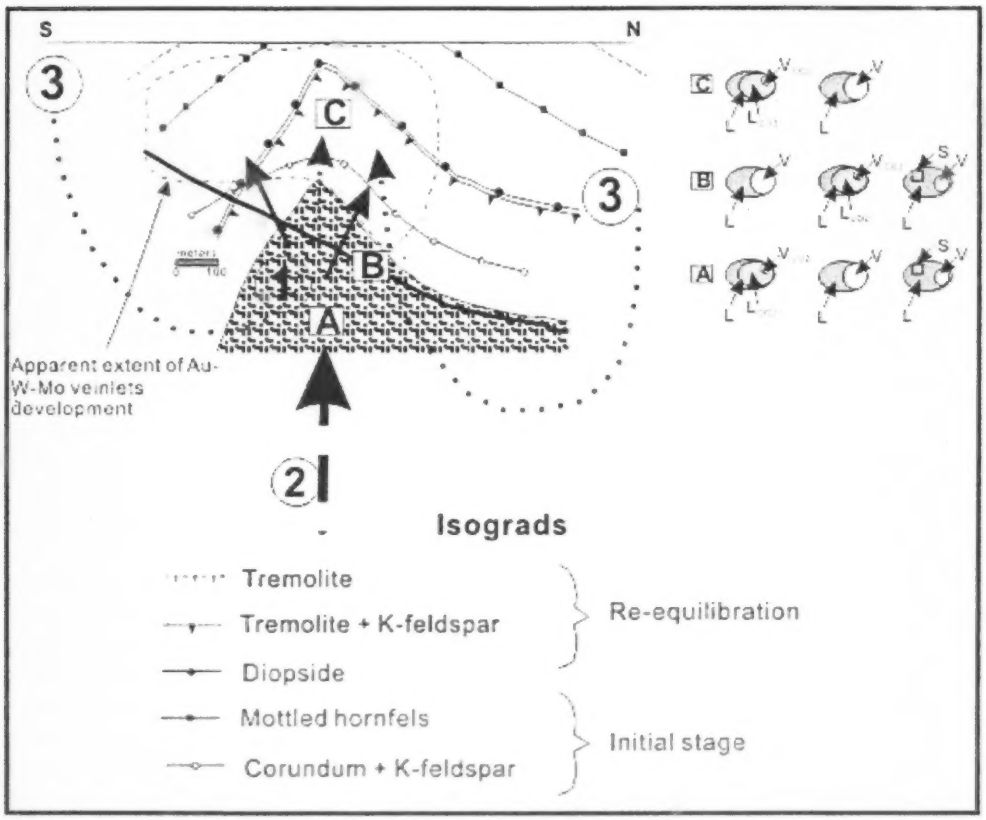

Figure 2. A model for the hydrothermal systems that interacted with the Lake George granodiorite stock and related Au-W-Mo-Sb mineralization. 1 - Solid arrow: magmatic hydrothermals; 2 - Dashed arrow: Fluids derived from cooling magmas at depth; 3 - Dotted arrow: circulation of ground water. A - the Lake George granodiorite stock; three types of inclusions occur: CO_2-bearing, H_2O-rich aqueous, and halite-bearing fluid inclusions. B - The Hibbard Sb ore vein; three types of inclusions occur: CO_2-bearing, H_2O-rich aqueous, and halite-bearing fluid inclusions. C - Apparent extent of Au-W-Mo veinlet and stockwork development; two types of inclusions occur: CO_2-bearing, and H_2O-rich aqueous fluid inclusions. Location of cross section N-S is shown in Fig. 1b; the isograds were modified from Seal et al. (1987) and Procyshyn & Morrissy (1990).

Au-W-Mo Skarn and Vein-Style Mineralization

Lake George contains gold mineralization described as skarn and stockwork veins associated with scheelite-molybdenite mineralization spatially and temporally related to the cupola region of the Granodiorite intrusion (Seal II et al., 1988; Procyshyn and Morrissy, 1990; Ruitenberg et al., 1990; Caron, 1996; Lenz, 2002a). Stockwork mineralization extends into the upper parts of the cupola, indicating that the mineralizing episode is either synchronous with granodiorite emplacement or post-dates it. Seal II et al. (1988) reported a K-Ar age from a Stage II hydrothermal muscovite (411 and 413 Ma ± 8 Ma), which is coeval with the age of the Lake George Granodiorite. The Au-W-Mo mineralization is generally confined to the contact aureole

(within the biotite zone) of the granodiorite stock. Seal II et al. (1987, 1988) documented three stages of W-Mo mineralization (Type Ia,b,c) bracketing the emplacement of the quartz-feldspar porphyry and lamprophyre dykes; further work needs to be done to confirm that some of these veins (Type Ia) predate the lamprophyric dykes.

Irregular fracture-fill stockwork quartz-carbonate veining with distinct well-developed pyrite-arsenopyrite [± loellingite ($FeAs_2$)] hydrothermal alteration halos (vein mantled by blue-grey, then yellow-orange buff, and then orangish red alteration halos) has been noted in the gold drift (850 level) and within drill holes on the mine property (Morrissy, 1991a, b; Caron, 1996). The dilatant nature of these sulphide-quartz-carbonate veins is reminiscent of a hydrofracture vein network. The veins contain fibrous mineral growths, although are locally recrystallized (sub-grained), especially if subjected to deformation. These grey to orangish buff alteration zones reflect varying proportions of very fine-grained pyrite, arsenopyrite, carbonate, and fine-grained muscovite with intergrown rutile (see Caron, 1996). In many cases, these replacement zones preserve the earlier tectonic fabric, i.e. are not recrystallized hydrothermally nor always annealed. The molybdenite-bearing quartz veins seem to merge with the gold-bearing alteration system. However, the same vein can be offset by a subhorizontal, later carbonate-bearing veins that resembles gold-bearing alteration zones. Detailed examination of a small dextral offset shows that the late vein is brittle with a lower degree of grey alteration on the selvage. It is evident that for at least some molybdenite-bearing quartz veins, the alteration zone mantling these veins is much more restricted than the alteration episode associated with gold mineralization. Irregular to nodular calc-silicate pods are overprinted by the zoned gold-bearing vein systems. The gold-related vein and alteration system is cut by the large shallowly dipping, antimony-quartz vein system that also has an alteration halo. Zoned alteration associated with quartz-carbonate veins, however, is not restricted to the gold drift/room, but has also been noted on the rest of the 850 level, with minor shear displacements that have weaker degrees of alteration mantling them that may be cored by vein filling minerals.

Caron (1996) has compared the alteration halos and found many gross similarities associated with the various mineralizing events discussed above. These similarities may indicate a continuum in the evolution from the W-Mo-Au to the Sb-Au system. The most significant gold mineralization is hosted within a hydrothermally altered stockwork and breccia zone that occurs 25 m in the hanging wall of the Hibbard vein on 850 level. The genetic relationship of these quartz-carbonate-rich stockwork and breccia zones to the stibnite-quartz vein system is uncertain (Caron, 1996), although from the similarities in elemental associations, they seem to be related to the W-Mo contact metasomatic event. The close spatial relationship of the distinctive gold-bearing, sulphide-quartz-carbonate vein system in the hanging wall to the Hibbard antimony-quartz vein mineralization is important to consider. Negligible amounts of carbonate are present in the Hibbard vein, however, crustiform quartz lining the walls of the vein contains breccia-like fragments; these breccias may represent scaling of the wall rocks during seismic pumping events. At least in some parts, it seems that the antimony vein is simply dilatant in character with minimal offset parallel to the vein across the lamprophyre dike-sediment contact. In many other parts of the mine, the stibnite-quartz veins are brecciated (angular hydrothermal quartz and altered sediment clasts) with stibnite remobilized into the matrix with recrystallized quartz. The tectonically brecciated stibnite-quartz veins (brittle) are also faulted.

The exploration of the stockwork and breccia zone described above, resulted as a follow up on gold assays from an earlier drill hole that returned 7.5 g/t Au over 2 m. Underground exploration delineated this gold-bearing structure, which gave an average 0.086 oz/T (2.95 g/t) Au over a length of 86 feet (26.2 m) with an average width of 9.7 feet (2.96 m) (Morrissy, 1991b). Up to 0.54 oz/T (18.5 g/t) is reported in one particular sample (Morrissy, 1991b).

Arsenopyrite (70%), pyrite (25%), and minor (< 5%) rutile, titanite, pyrrhotite, sternbergite ($AgFe_2S_3$), tetrahedrite [$(Cu,Fe)_{12}Sb_4S_{15}$], stibnite, native antimony, chalcopyrite, berthierite ($FeSb_2S_4$), and molybdenite were observed in a sample (87-203) of the gold-rich ore (Davison, 1988). The association with molybdenite, negligible stibnite, and native antimony suggests that this mineralizing episode is related to the earlier W-Mo mineralizing episodes. In that study, two very fine grains of native gold were observed in fractured arsenopyrite. Based on the rare occurrence of native gold, Davison (1988) suggested that much of the gold was submicroscopic within pyrite and arsenopyrite. Process testing of a pyrite- and arsenopyrite-rich sample of the gold-rich ore (10.0 g/t), yielded poor recoveries consistent with Davison's theory (Harris, 1990).

As stated by previous researchers (Seal II et al., 1988; Procyshyn and Morrissy, 1990; Ruitenberg et al., 1990), the close spatial and temporal relationship of the Au-W-Mo mineralization to the granodiorite along with high depositional temperatures associated with quartz and ore minerals obtained from fluid inclusion data in Type I and III mineralization (Scratch et al., 1984; Seal II et al., 1987), support a magmatic-hydrothermal source. This convinced Yang et al. (2002a, b) that continued vapor exsolution associated with crystallization of the pluton during emplacement and cooling was responsible for the contact metasomatic deposit.

Au-Bearing Sb Vein System

The anastomosing and locally undulating stibnite-rich veins (e.g., Prout and Hibbard) are typically less than 2 metres wide, strike east-west and dip shallowly (33°) to the north (Fig. 1b and 2). A north-northeast-trending, shallowly east-dipping vein (Lawrence) is located on the southwest end of the mine site. This antimony vein system cross cuts the granodiorite porphyry and has been dated by K-Ar (phyllic alteration) at 417 ± 8 Ma (Seal II et al., 1988), thus indicating consistency in the ages and the mineralization is closely related to the intermediate magmatism in the region. Details of the grade and tonnage figures for the antimony deposit are referred to Procyshyn and Morrissy (1990).

The gold grades in the stibnite-rich veins (based on only a few analyses) are relatively low (110 ppb, n = 15; Scratch et al. 1984), but significant variations are known. Pyrite (72%), arsenopyrite (15%), pyrrhotite (4%), marcasite (3%), stibnite (2.5%), native antimony (1%), and less than 1% for magnetite-ilmenite, hematite-goethite, chalcopyrite, tetrahedrite, sphalerite, berthierite, and sternbergite are the phases recognized in the mill tailings sample (Davison, 1988); no native gold was observed in the sample, therefore, it was inferred that the gold was hosted in arsenopyrite. In addition to these phases, Abbott and Watson (1975) and Kaiman et al. (1980) identified chalcostibnite ($Cu_6Tl_2SbS_4$), plagionite ($Pb_5Sb_8S_{17}$), fuloppite ($Pb_3Sb_8S_{15}$), bournonite ($PbCuSbS_3$), cubanite ($CuFe_2S_3$), and stibivanite (Sb_2VO_5) in the antimony ore. An assay of the mill tailings containing pyrite, with minor arsenopyrite, pyrrhotite, sphalerite, and stibnite yielded 0.35 g/t Au. This sample was gravity concentrated (3200 percent) to 11.2 g/t Au (Harris, 1990) for metallurgical testing. Seven tailings assays for Au, As, Sb, W (INAA - XRAL) by Caron (1996) yielded 334 ± 147 ppb, 4286 ± 553 ppm, 5057 ± 1218 ppm, 38 ± 7 ppm, respectively. Process testing confirmed that gold in the tailings was refractory and occurred as submicroscopic inclusions or in solid solution in pyrite and (or) arsenopyrite (Harris, 1990). Based on a preliminary examination of these ores petrographically, and using EPMA and scanning electron microscopy (SEM) at the University of New Brunswick, no native gold was found in a sample from the antimony vein. Therefore, gold seems to be tied up in other sulphides such as pyrite and arsenopyrite, although solid solution in stibnite and native antimony cannot be ruled out. If gold

was in solution with native antimony (very minor), then gold grades might be higher in the western parts of the antimony vein, where native antimony is more abundant.

Using geochemical data from Scratch et al. (1984), there is a significant correlation between Sb and As in the vein, although gold content varies independently of Sb and As content of the stibnite vein. Overall, the lack of association of gold with Sb and As is consistent with the relatively high abundance of pyrite in the antimony deposit compared to arsenopyrite (Lentz et al., 2002a).

Conclusions

The Lake George Sb-Au-W-Mo polymetallic mineral deposit, York County, New Brunswick (NTS 21 G/14), is spatially and temporally associated at depth with an unexposed Early Devonian porphyritic granodiorite stock. An extensive zone of gold mineralization is associated with disseminated replacement and veinlet styles of W-Mo mineralization within the contact aureole of the granodiorite stock, and stibnite-quartz mineralized veins. These features indicate that Au mineralization at Lake George is closely related to the granodiorite intrusion. The reduced I-type (ilmenite-bearing) granodiorite displays metaluminous to weakly peraluminous and calc-alkaline features, with K_2O/Na_2O ratio < 1, which are broadly comparable to those considered to be favourable for intrusion-related gold systems in eastern Alaska, USA and Yukon Territory, Canada. The trace element characteristics (including rare earths) imply that the granodiorite may have been derived by partial melting of arc-like lower continental crust in a volcanic arc to late orogenic environment. The granodiorite stock is genetically linked with the Hawkshaw granite within the polyphase Pokiok Batholith through crystal fractionation, particularly hornblende separation.

Studies of detailed mineral compositions and petrology show that the Lake George granodiorite has reacted with multiple generations of hydrothermal fluids, in which CO_2-bearing fluids of low salinities dominate, resulting in the signature of magmatic equilibration being partially to completely erased. Those fluids may have progressively emanated from the granodiorite as it cooled at depth. Low $Fe^{3+}/(Fe^{2+}+Fe^{3+})$ ratios both in amphibole (ave. 0.07) and biotite (ave. 0.06), the presence of ilmenite as the predominant Fe-Ti oxide, and low magnetic susceptibility (ave. 6×10^{-5} SI), indicate reducing conditions of the magma, as well as associated magmatic fluids. The high-temperature (350° ~ 580°C), low-salinity, and CO_2-rich fluids were favorable for Au, Sb, W, and Mo melt-fluid partitioning from the ascending granodioritic magma and resulted in formation of stockwork mineralization within the granodiorite and the contact metamorphic aureole.

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Stops

It is impossible to take an underground tour of the Lake George Mine because it was closed and flooded in the mid 1990's. However, the drill core storage and tailings at the Lake George Mine site will be visited.

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